SPRING AND SUMMER DISTRIBUTION OF HADDOCK ON GEORGES BANK

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EXPLANATORY NOTE

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United States Department of the Interior, Douglas McKay, Secretary
Fish and Wildlife Service, John L. Farley, Director

SPRING AND SUMMER DISTRIBUTION OF HADDOCK ON GEORGES BANK

By

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ABSTRACT

This part of the study of the Georges Bank census data treats of the total age, and the age distribution of haddock over the Bank, by statistical subarea, by depth, and by bottom type in the years 1948, 1949, and 1950.

The total abundance and the age composition varied markedly from year to year and emphasized the effect of certain year classes on the catch.

The distribution by subarea demonstrated that the fish were concentrated in certain subareas and that the age composition of the catch varied with location. This distribution shifted slightly from summer to spring with the total abundance being greatest in subareas J and M in summer and greatest in subarea N in spring. The abundance of older haddock was consistently greater in subareas G and H than over the rest of the bank.

The depth distribution of mature fish varied with the season and appeared to be linked with the spawning and feeding migrations. In summer, greater numbers and heavier 5-year-old and older haddock were caught in water deeper than 90 fathoms, but in spring these older haddock were found in shoaler water. Few haddock of any age were found in depths between 60 and 90 fathoms during the summer months.

Haddock occurred in greater numbers over sand than over mud bottoms, but this distribution was incidental to the depth distribution.

Mortalities, although based on 2 years' data, were consistent and decreased with the increasing age of the fish and their decreasing availability to commercial capture.

Age-composition data of the commercial catch and of the census data, when weighted in terms of effort of the commercial fleet, were similar, a fact which attests to the reliability of the sampling methods.

Estimates of year-class strength based on the relative numbers of zero-ring haddock determined from census tows were substantiated by the catch of these year classes in subsequent years during census cruises and by the commercial fleet.

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INTRODUCTION

Systematic surveys of the populations of bottom fish in the Georges Bank area were made by the Fish and Wildlife Service vessel Albatross III during the summers of 1948 and 1949 and in the spring and summer of 1950. These surveys were conducted to estimate the size and composition of the populations of haddock and other species of demersal fish and to obtain information on distribution, movements, year class strength, and growth rates in relation to environmental conditions. This paper presents an analysis of the distribution of haddock (Melanogrammus aeglifinus) by area, depth, bottom type, season, and year.

The basic assumptions underlying this program were as follows:

1. The efficiency of any fishing gear remains constant, although it may vary with different species. Thus the catches of the net from different places and at different times are comparable.

2. The size and distribution of the population sampled does not change significantly during a short period, and thus all samples taken during this period are samples of the same area.

The distribution of the commercial catch in the Georges Bank area in time and space is well established from records collected over a number of years. These records show that the distribution varies somewhat with age of the fish and season of the year and that the population is not evenly distributed by area or depth. (Schuck 1952). Since the commercial fishermen concentrate their efforts in particular localities and depths and on certain sizes and species of fish (notably haddock), and since there is little uniformity in the size and the efficiency of the boats and gear used, these catch records do not give an accurate record of the distribution of the population over the bank. It was necessary, then, to establish a sampling program which insured the following:

1. Standardization of gear and methods.
2. A complete coverage of the bank in as short a time as possible.
3. Uniform sampling of all areas and depths of the bank.

Dr. William F. Royce and Howard A. Schuck planned the sampling program. Numerous persons assisted in the collection of data at sea. I am indebted to Captain John T. Collins and the crew of the Albatross III for their willing assistance and cooperation and to biologists E. D. Premetz, R. E. Sayles, E. L. Arnold, J. R. Webster, R. J. Buller, E. L. Miles, J. R. Clark, and R. E Kirkpatrick, who took part in many cruises.

Age determinations from scales were made by E. L. Arnold; R. E. Sayles and R. R. Marak assisted in compilation of catch records; and C. C. Taylor offered valuable suggestions and advice in the analysis of the data.

METHODS

Sampling Techniques

Adequate representation of all areas and depths was accomplished in the following manner:

1. The total area of Georges Bank within a limiting depth of 150 fathoms was computed and, using the statistical divisions of Rounsefell (1948), the total square mileage of subareas, G, H, J, M, N, and O were likewise determined.

2. The region to be sampled was further subdivided into unit areas of 10 minutes latitude by 10 minutes longitude. These unit areas represented potential trawling stations. The percentage which the number of unit areas in each subarea represented of the total number of unit areas in the region of sampling was then computed.

3. The number of samples that could be taken within a definite time limit, approximately one month, was estimated and this number was prorated to each of the subareas on the basis of their area.

4. Three depth zones were established as follows:

   (a) Depth zone I: 0-30 fathoms.
   (b) Depth zone II: 31-60 fathoms.
   (c) Depth zone III: 61-150 fathoms.

The percentage of each subarea lying within each of the three depth zones was then determined and the total number of samples to be taken in each subarea was prorated to each depth zone on the basis of these percentages.

After determining the number of stations to be allotted to each subarea and to each depth zone within each subarea, the stations to be occupied were determined by numbering the possible stations and selecting the ones to be occupied from a table of random numbers (Fisher and Yates, 1943). This random selection was restricted so that not more than three stations could be adjoining. To provide a measure of variability between tows, 2 tows were made at random stations in 1948 and at every third station in 1949 and 1950.

The area and subarea boundaries and distribution of stations are shown in figure 1.

Georges Bank was sampled in this manner in the following months and years:

Year	Months
1948	July - October
1949	July - August
1950	April
1950	July - August

The catch per tow was adopted as an index of abundance. In the age classification of haddock, it is assumed that haddock spawn in February and hence a haddock-year extends from February of one year to February of the following year. Haddock which were spawned the preceding February and hence in their first year of life are referred to here as zero-ring haddock, and are fish with no annulus on their scales. Fish in their second year of life, having scales with one annulus are called one-year-olds (I-ring), fish in their third year, two-year-olds (II-ring), and so on. The category, nine-year-olds, includes the nine-year-old and all older fish. Age readings were determined from scales obtained from fish caught during census cruises and by the commercial fleet in corresponding periods.

The gear used was a slightly modified No. 1-1/2 Iceland Trawl with dimensions as follows: 78 ft. head rope; 114 ft. foot rope; 6-inch mesh in the wings and square; 5-inch, tapering to 4-inch, mesh in the belly; and 4-inch mesh in the cod end. The cod end and upper belly were lined with 1-1/2-inch mesh cotton twine, as earlier experiments had shown that these were the places where most of the small fish pass through the mesh. The entire net was approximately 100 feet long and was attached to the doors by rope pennants 30 feet long. The doors were fastened directly to the towing warps. Three 20-foot sections of wooden rollers were used, the largest of which were about 18 inches in diameter and 4 to 6 inches in width.

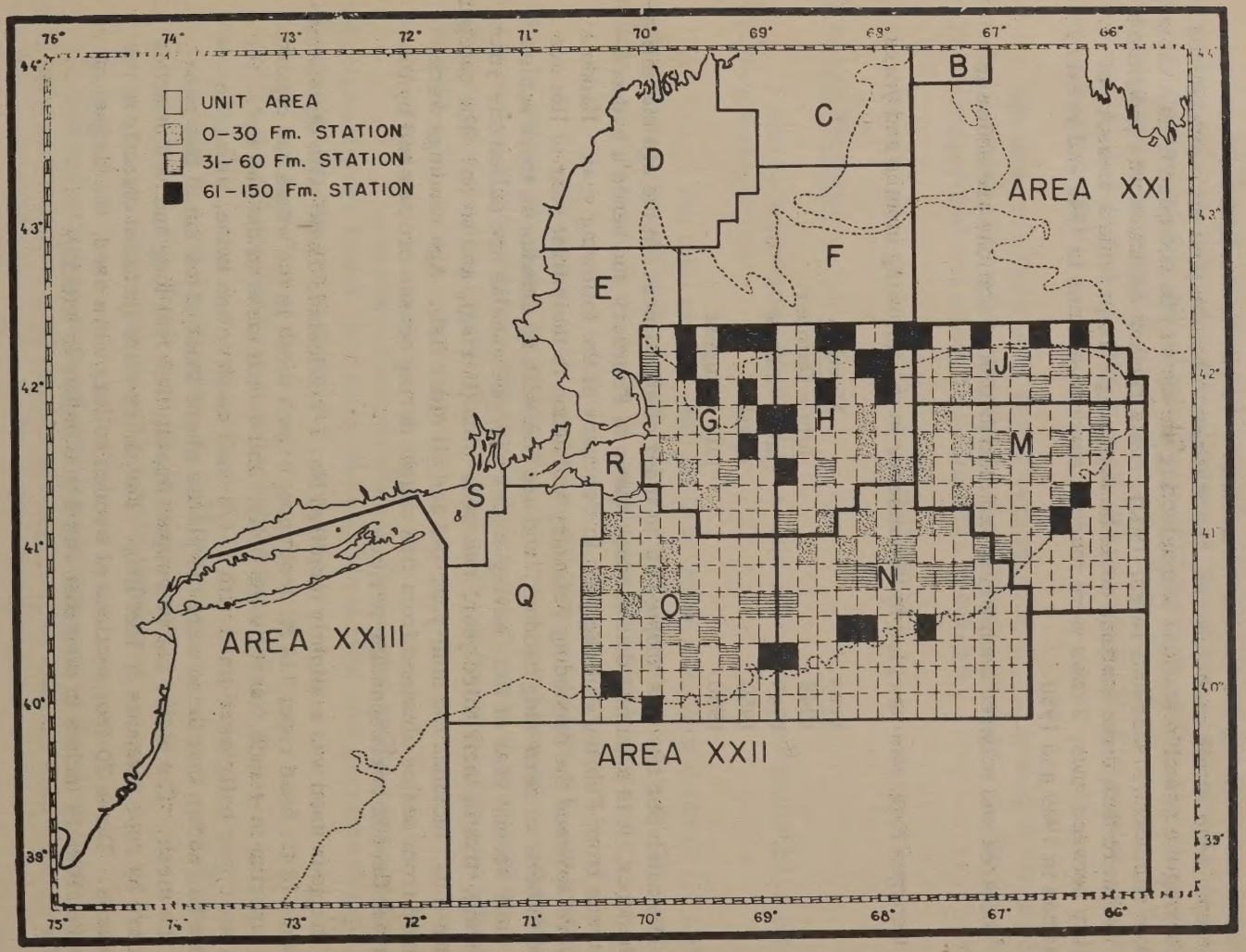

Figure 1.--Statistical areas and station distribution.

Station Routine

The trawl was towed for 1/2-hour at a towing speed of approximately 4.5 knots with each tow being made within the unit area boundary and in the same depth (± 10 fathoms) wherever possible.

At each station the following additional observations and collections were made:

1. Bathythermograph and surface temperature readings.
2. Bottom samples by means of a scoop-fish bottom sampler attached to the nose of the bathythermograph.
3. Loran fixes at the beginning and end of each tow.
4. Fathometer records.
5. Counts or accurate estimates of the number of fish and the number of bushels of fish of all species.
6. Length measurements of all haddock and of other species as time permitted.
7. Scale samples of as many haddock as possible.

RESULTS

Abundance and Age Composition for Georges Bank

Summer

Since most of the surveys were conducted during the summer months the results obtained during this season will be discussed first. The total catch per tow of haddock and the catch per tow by ages for all of Georges Bank for each of the three survey years are presented in figure 2 and table A-1. The total catch per tow varied markedly during the 3 years, with a maximum of 134 in 1949 and a minimum of 37 in 1948. These differences in the total catch per tow were due mainly to differences in numbers of younger fish (0 to 3-year-olds) or more specifically to the abundance of the 1948 year class.

The zero-ring group was not adequately sampled for it will be noted that the abundance of one-year-old haddock in 1949 and 1950 was greater than the abundance of zero-ring fish in the respective preceding year. The catch per tow of zero-ring fish does, however, serve as an indication of year class strength as seen in the catch-per-tow data of subsequent years. Part of this inadequate sampling may be attributed to the escape of the smallest haddock through the 1-1/2-inch liner. However, there is evidence that some Georges Bank haddock inhabit during their first year of life areas outside of Georges Bank and thus outside the area sampled.

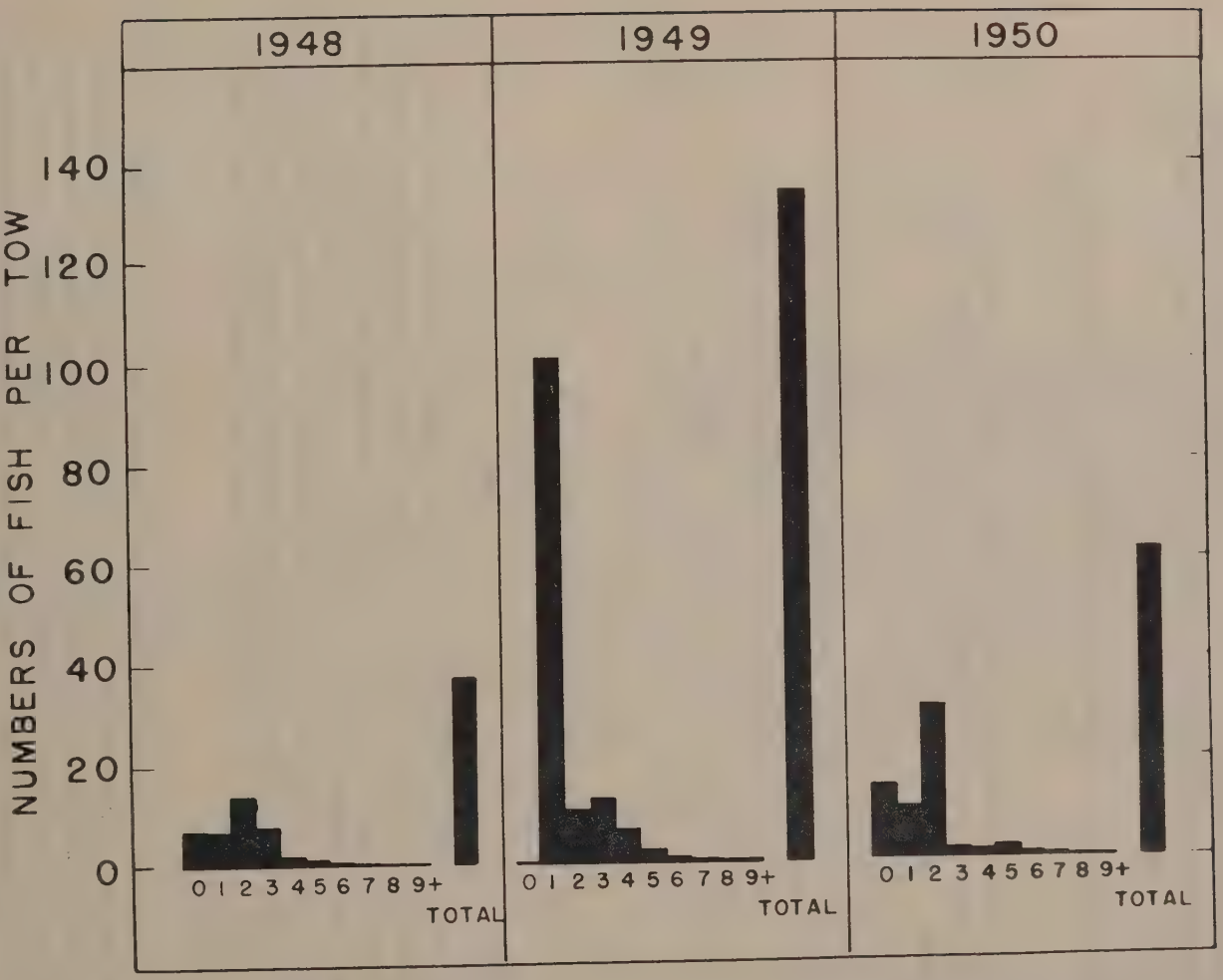

Figure 2.--Total catch per tow and catch per tow of individual ages for the entire area of Georges Bank, Summer.

Although only Georges Bank was surveyed consistently with the Albatross III, occasional trips were made to adjacent areas (Subareas E, F, and Q in area XXII and area XXIII) and in these locations the concentration of zero-ring haddock was sometimes greater than that on Georges Bank. The abundance of zero-ring haddock in all locations sampled is shown in figure 3.

It appears likely that the Georges Bank stock of haddock may be dependent, at least in part, upon the immigration of immature fish from off the bank proper, and that these very young migrants may have been spawned either on the bank or in the Gulf of Maine.

Some of the 1948 data are inconsistent with the 1949 and 1950 records. For instance, the abundance figures for 2, 5, 7, and 9-year-old fish in 1949 were greater than those for 1, 4, 6, and 8-year-old fish in 1948. It is our opinion that the sampling technique was not so good in 1948 as in other years. Another indication of this is the lower number of species per tow and the greater number of tows with 0, 1, and 2 species in that year (Taylor 1953). The reason for this poorer sampling in 1948 is not immediately apparent for, as seen in table 1, the number of tows by subarea, depth, and bottom type were consistent with those of other years. One way in which the 1948 sampling technique differed from that of 1949 and 1950 was in the time required to cover the designated area. In 1948, 97 days were required to sample the area, while in 1949 and 1950, 23 and 53 days, respectively, were needed. Also, during the 1948 cruises towing speeds varied considerably which possibly contributed to the sampling error. Because of this discrepancy only the 1949 and 1950 data were used in estimating mortality rates and in determining mean values.

Since the catch per unit of effort varied markedly from year to year, the age composition was expressed as percentages of the total catch per tow in order to give a clearer picture of the differences in the age composition of the catch during the three years. These percentages are shown in figure 4.

In 1948, more than 90 percent of the catch was made up of 0-3-year-old fish, with 2-year-old fish predominant (37 percent). In 1949, over 90 percent of the catch consisted of 1 through 3-year-old fish with 1-year-old fish predominant (75 percent). The percentage of zero-ring fish in 1949 was negligible. In 1950, 89 percent of the catch were in the 0 through 2-year age group with 2-year-old fish predominating (49 percent). The relative high percentage, as well as actual numbers, of zero-ring fish in 1950 indicates a successful 1950 year class, and the low percentage and numbers of 1-year-old fish, indicates the weakness of the 1949 year class. The slightly higher percentage of 5-year-old fish, which were found principally in subareas G and H in 1950, is not readily explainable from the age composition of the 1948 and 1949 catches.

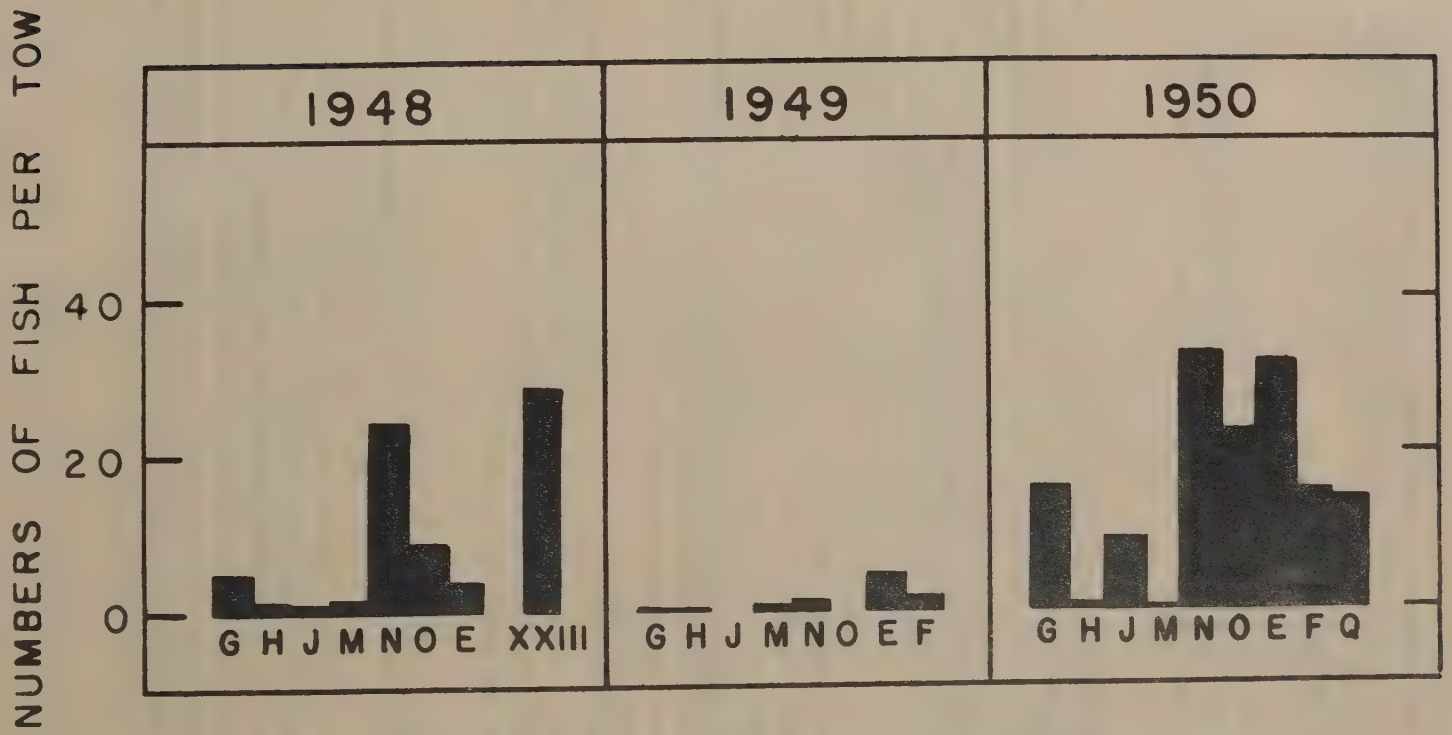

Figure 3.--Abundance of zero-ring haddock by area and subarea, Summer.

TABLE 1.--Number of tows by subarea, bottom type, and depth zone

Type of bottom	Subarea G	H	J	M	N	O	Total	Depth zone (in fathoms)	Subarea G	H	J	M	N	O	Total
Summer of 1948	Number of tows								Number of tows						
Sand	9	13	13	17	22	12	86	0-30	3	2	3	6	5	8	27
Stony	0	0	8	6	0	0	14	31-60	4	7	12	12	14	16	65
Mud	13	2	0	1	0	7	23	61-90	3	1	1	4	7	3	19
Mud and sand	1	5	1	0	4	8	19	90-150	13	10	6	2	0	0	31
Total	23	20	22	24	26	27	142		23	20	22	24	26	27	142
Summer of 1949															
Sand	8	11	1	16	20	10	66	0-30	4	5	0	7	6	5	27
Stony	0	5	10	8	0	0	23	31-60	2	2	7	14	12	16	53
Mud	12	1	0	0	0	6	19	61-90	1	3	0	3	5	3	15
Mud and sand	0	2	0	0	4	8	14	91-150	13	9	4	0	1	0	27
Total	20	19	11	24	24	24	122		20	19	11	24	24	24	122
Summer of 1950															
Sand	7	11	1	16	16	16	67	0-30	3	8	1	5	5	10	32
Stony	0	1	11	5	1	0	18	31-60	2	6	6	15	12	13	54
Mud	9	2	0	0	0	4	15	61-90	4	3	1	2	5	1	16
Mud and sand	1	6	2	1	5	6	21	91-150	8	3	6	0	0	2	19
Total	17	20	14	22	22	26	121		17	20	14	22	22	26	121
Spring of 1950															
Sand	—	11	1	15	21	—	48	0-30	—	5	1	7	8	—	21
Stony	—	3	11	6	0	—	20	31-60	—	3	7	11	12	—	33
Mud	—	2	0	0	0	—	2	61-90	—	3	0	3	5	—	11
Mud and sand	—	3	1	0	4	—	8	91-150	—	8	5	0	0	—	13
Total		19	13	21	25		78			19	13	21	25		78

From the catch per tow and percentage age composition data (figs. 2 and 4) it is seen that 1946, 1948, and 1950 were years in which spawning was relatively successful. The effect that these years of successful spawning have on the catches of the following years is exemplified by the effect that the 1948 year class had on the catch per tow data for 1949 and 1950. The success of the 1948 and 1950 year classes has been further substantiated by the landing of the commercial fleet (Schuck and Clark, 1950). These two year classes have been the mainstays of the haddock fishery during recent years. It is thus evident that census surveys such as those conducted with the Albatross III during 1948 to 1950 can be very useful in predicting the commercial catch several years in advance.

Mortality rates can also be estimated from surveys of this kind. However, it must be emphasized that these rates are based on an extremely limited sample and as pointed out by Rounsefell and Everhart (p. 15, par. L-9, 1953), it is unsafe to draw any conclusions from them without further verification. In table 2 are presented the mortalities in percentage for various age fish, based on the catch per tow data for 1949 and 1950.

The indicated mortality rate is higher in 1-to-4-year-old fish than in 5-to-8-year-old fish. Zero-ring fish were not included because of inadequate sampling, but natural mortality probably makes up a large proportion of the total mortality of these recently spawned fish which occur generally in areas outside those fished extensively by the commercial fleet and are also not retained by the commercial-size gear. The commercial fleet begin catching haddock during their second year (one-year-olds) and one and two-year-old fish make up the bulk of the fish discarded at sea. Thus fishing mortality appears to be an important factor in the depletion of even these younger fish. Young fish occur in large concentrations and in the same locations as the older fish and it is this combination of availability and large numbers that most likely accounts for their high mortality rates.

Commercial catch records indicate that older haddock (5 years) tend to move to deeper water off the northern edge of Georges Bank where fishing intensity is much less, which fact might explain the decrease in mortality rate of these fish. This movement of older fish into deeper water will be discussed further when the distribution in relation to depth zones is considered.

Although these mortality rates are based on only 2-years data, and subject to numerous errors, indications are that of a sample of 100 one-year-old fish only 5 of these survive to be 3-year olds. Having an accurate knowledge of these mortality rates and their relation to changes in fishing effort, it should be possible by using a similar sampling technique to predict the numbers of marketable fish available in future years from a sample of one-year-old fish. An even better method

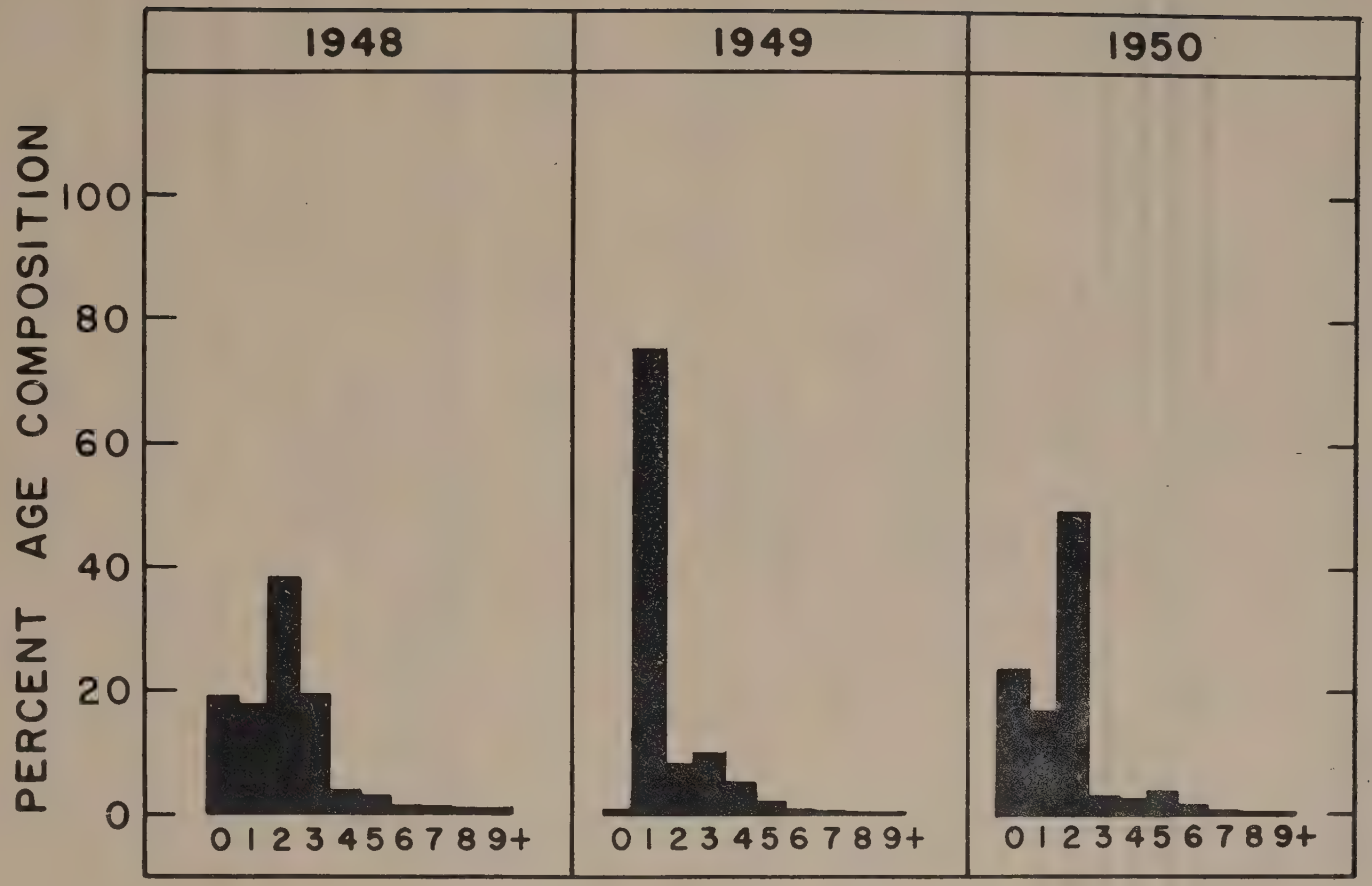

Figure 4.--Percentage age comparison of the total catch per tow, for all Georges Bank, Summer.

for making early predictions would be to devise a means of adequately sampling the zero-ring haddock which are found concentrated in definite areas completely separated from other year classes and not subject to fluctuating fishing intensity.

Spring

A survey was made during this season only in 1950 and only in subareas H, J, M, and N. The distribution of tows in each subarea, depth zone and bottom type was the same as that in the summer months (table 1). The catch per tow of each age and the percentage age composition are presented in table 3. The predominance in the catch of the 1948 year class (2-year-olds) is again demonstrated.

Table 2.--Mortality rates (percent) in various age groups

Item	Summer of 1949 age group						
	1	2	3	4	5	6	7
Catch per tow	100.3	10.4	12.5	6.7	2.1	0.73	0.38
	Summer of 1950 age group						
	2	3	4	5	6	7	8
Catch per tow	30.3	1.8	1.6	2.2	0.8	0.43	0.15
Mortality rate (percent)	70.00	82.7	87.2	67.2	61.9	41.1	60.5

Table 3.--Catch per tow and percentage of age composition in various age groups

Item	Spring of 1950 age group									
	1	2	3	4	5	6	7	8	9+	Total
Catch per tow	13.11	64.84	5.93	4.51	3.64	1.22	0.63	0.20	0.26	94.34
Percentage	13.90	68.73	6.29	4.78	3.86	1.28	0.67	0.21	0.28	100.00

As no records are available for this season for other years, no direct comparison by season can be made. However, because the mortality rates based on 1949 and 1950 data for July and August appear considerably higher than rates based on commercial landings (Schuck and Taylor, in press) and show a decrease in mortality with increasing age while the commercial data show an increase with increasing age, it is of interest to estimate mortalities on the basis of the spring of 1950 and summer of 1949 data. If fishing intensity were constant, numerical mortality based on this 9-month period should be considerably lower because of the shorter time lapse between successive samplings of the populations and should serve as a check on reliability. Only subareas H, J, M, and N could be used for the comparison of mortalities. The catch per tow for these subareas for 1949 and 1950 (summer), and 1950 (spring), and the calculated mortalities are given in table 4.

Table 4.--Comparison of mortalities based on catch per tow data for summer of 1949 and 1950, and spring of 1950 in subareas H, J, M, and N

Item	Summer of 1949 Age group						
	1	2	3	4	5	6	7
Catch per tow	141.0	15.0	18.4	7.3	2.0	0.6	0.3
	Spring of 1950 Age group						
	2	3	4	5	6	7	8
Catch per tow	64.8	5.9	4.5	3.7	1.2	0.6	0.2
	Summer of 1950 Age group						
	2	3	4	5	6	7	8
Catch per tow	46.2	2.5	2.2	2.8	1.0	0.5	0.16
	Mortality (percent)						
Summer, 1949 to Spring, 1950	51.2	59.8	75.5	49.7	38.5	0	37.5
Summer 1949 to Summer 1950	67.2	83.5	87.8	61.0	53.5	23.8	50.0

The numerical mortalities are indeed consistently lower for the shorter time lapse. That spring and summer distributional differences do not invalidate this comparison is evidenced by the fact, which will be shown in a later section, that distributional differences of the various age groups are merely found in relation to depth and not to subarea. Therefore, all age classes were uniformly sampled as regards the four subareas under consideration.

Abundance and Age Composition in Individual Subareas

Summer

The catch per tow (total and by ages) and the percentage age composition by subarea for the years 1948, 1949, and 1950 and the 1949-1950 means are presented in figures 5 and 6 and table A-2. Upon comparing the histograms for the three years, it is apparent that poor catches in subarea M in 1948 were responsible for the discrepancies previously mentioned. In 1949 and 1950 the major portion of the fish were found in subareas J and M which was as expected from the catch records of the commercial fleet.

In order to evaluate subareas as regards availability of fish, the mean catch per tow for each year was assigned a value of unity. The index number was then determined for individual subareas relative to this value. These comparisons are presented in figure 7.

As stated above, the catches in subareas J and M were consistently high while the catches in other subareas fluctuated considerably from year to year with subarea O usually having the poorest yield.

Two-year-old fish were dominant in the 1948 catches (figs. 5 and 6) and this predominance held true for all subareas except G, N, and O. In subareas N and O zero-ring fish made up the greater proportion of the catch, while in subarea G, 3-year-old fish were most plentiful. Subareas G and H were distinct in that they were the only subareas in which an appreciable number of fish older than 4 years were caught.

In 1949 the catch per tow was greatest in subarea M and one-year-old fish dominated the catch in all subareas with the exception of G and J where 3 and 4-year-old fish, respectively, prevailed. In subareas N and O no fish older than 2 years were caught. The proportion of older fish (5 years) was greatest in subareas G and H, although the total abundance was less than in other subareas.

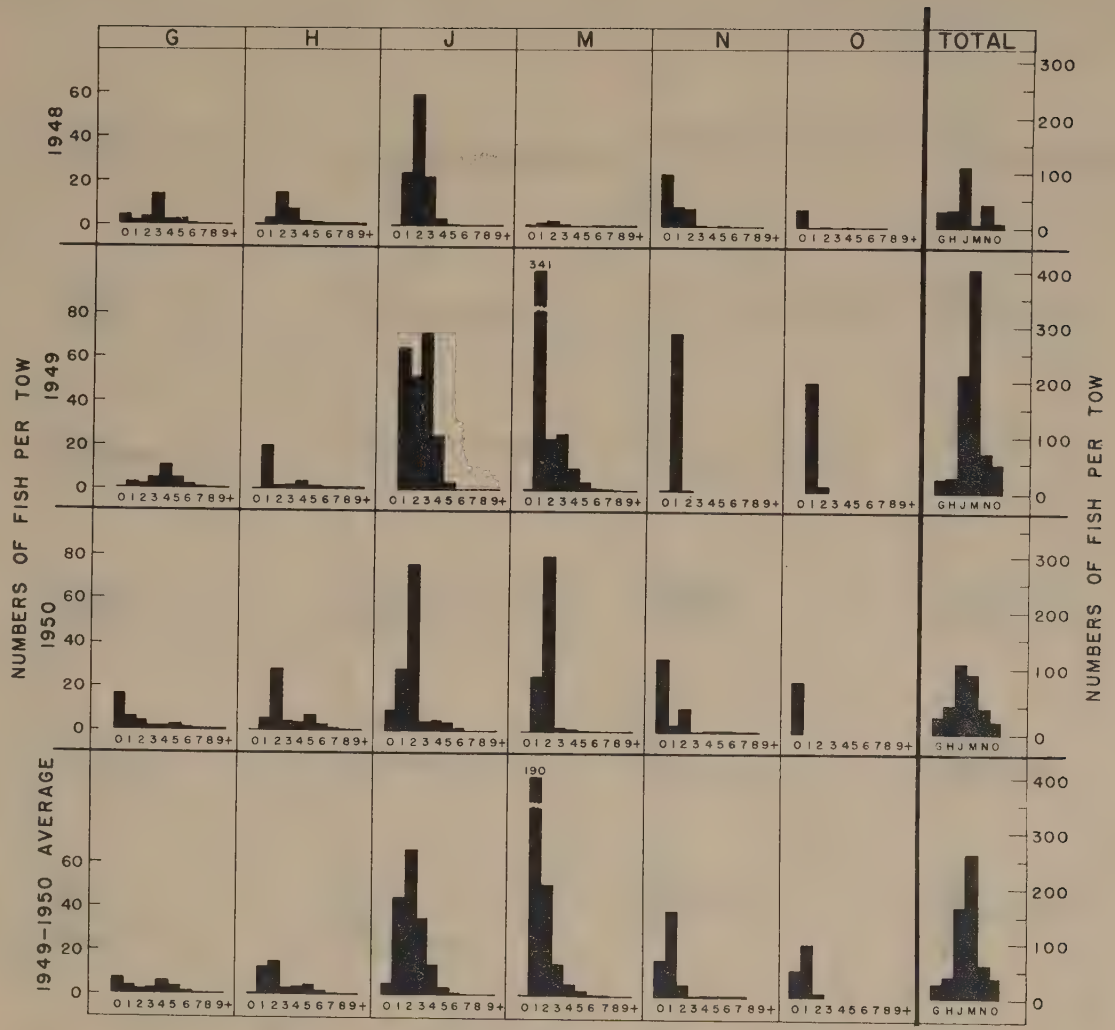

Figure 5.--Total catch per tow and catch per tow of individual ages by subarea, Summer.

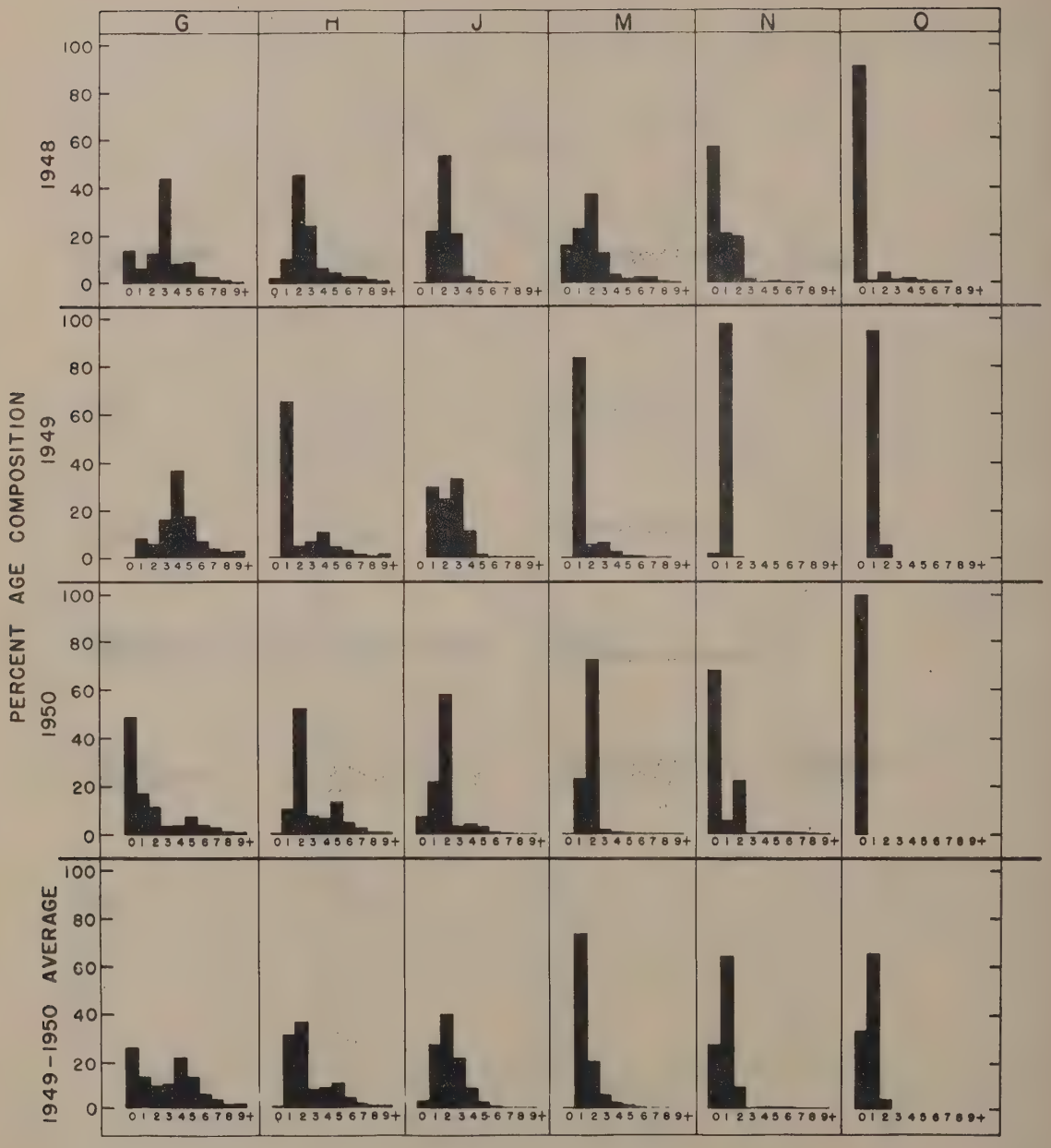

Figure 6.--Percentage age composition based on the catch per tow by subarea, Summer.

In 1950, the catch per tow was greatest in subareas J and M with 2-year-old fish making up the bulk of the total catch. Two-year-old fish dominated the catches in subareas H, J, and M while zero-ring fish prevailed in subareas G, N, and O. Subareas G and H again had the highest proportion of 5 year and older haddock and in subareas N and O very few fish older than 2 years were caught.

To summarize the subarea distribution in the summer, it may be stated that:

1. In all three years the catches of haddock 5 years and older were greater in subareas G and H than over the rest of the bank. This fact is more graphically illustrated in the following table (table 5) giving the catch per tow and percentage of 5 year and older haddock by subarea.

2. Subareas J and M had consistently the greatest concentration of haddock, but the greater proportion of these fish were 1-to-3-year-olds.

3. In subareas N and O the catches were made up principally of zero-ring and one-year-old fish with older fish seldom observed.

Table 5.--Catch per tow and percentage age composition of 5-year and older haddock by subarea

Subarea	Item	1948 Summer	1949 Summer	1950 Summer	1950 Spring	Average 1949-1950 Summer
G	Catch per tow	4.88	9.20	5.09	No sample	7.32
	Age composition	15.7	33.0	15.5	---	24.3
H	Catch per tow	3.96	3.71	11.37	12.49	7.62
	Age composition	12.3	12.4	21.5	30.0	18.3
J	Catch per tow	1.56	4.35	5.98	4.23	5.27
	Age composition	1.4	2.0	4.6	6.2	3.1
M	Catch per tow	0.46	5.82	1.08	5.71	3.55
	Age composition	8.2	1.4	1.0	5.4	1.3
N	Catch per tow	0.31	0	1.19	2.15	0.56
	Age composition	0.7	0	2.4	1.6	0.9
O	Catch per tow	0.08	0	0	No sample	0
	Age composition	0.09	0	0	---	0

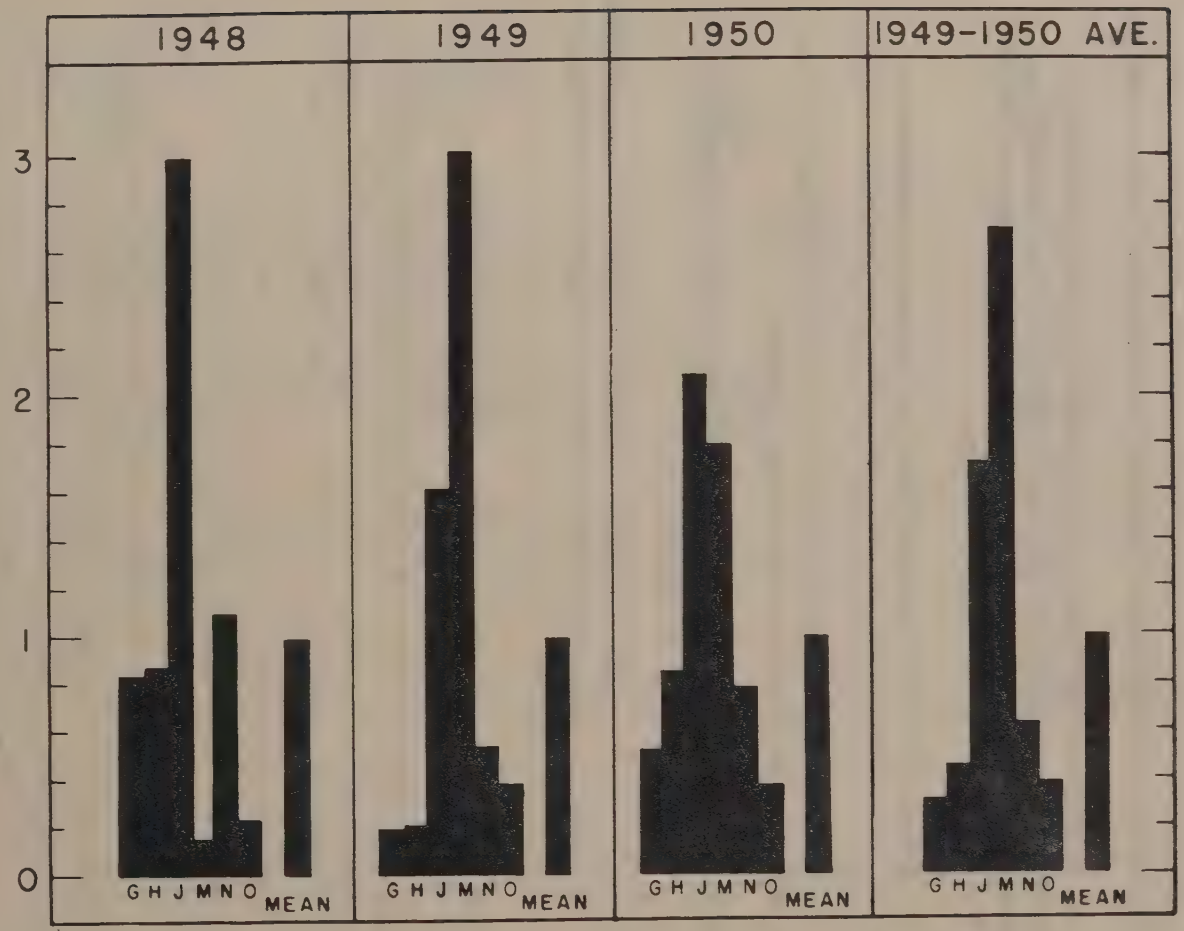

Figure 7.--Total catch per tow for the various subareas related to the mean for all subareas (mean=1.00), Summer.

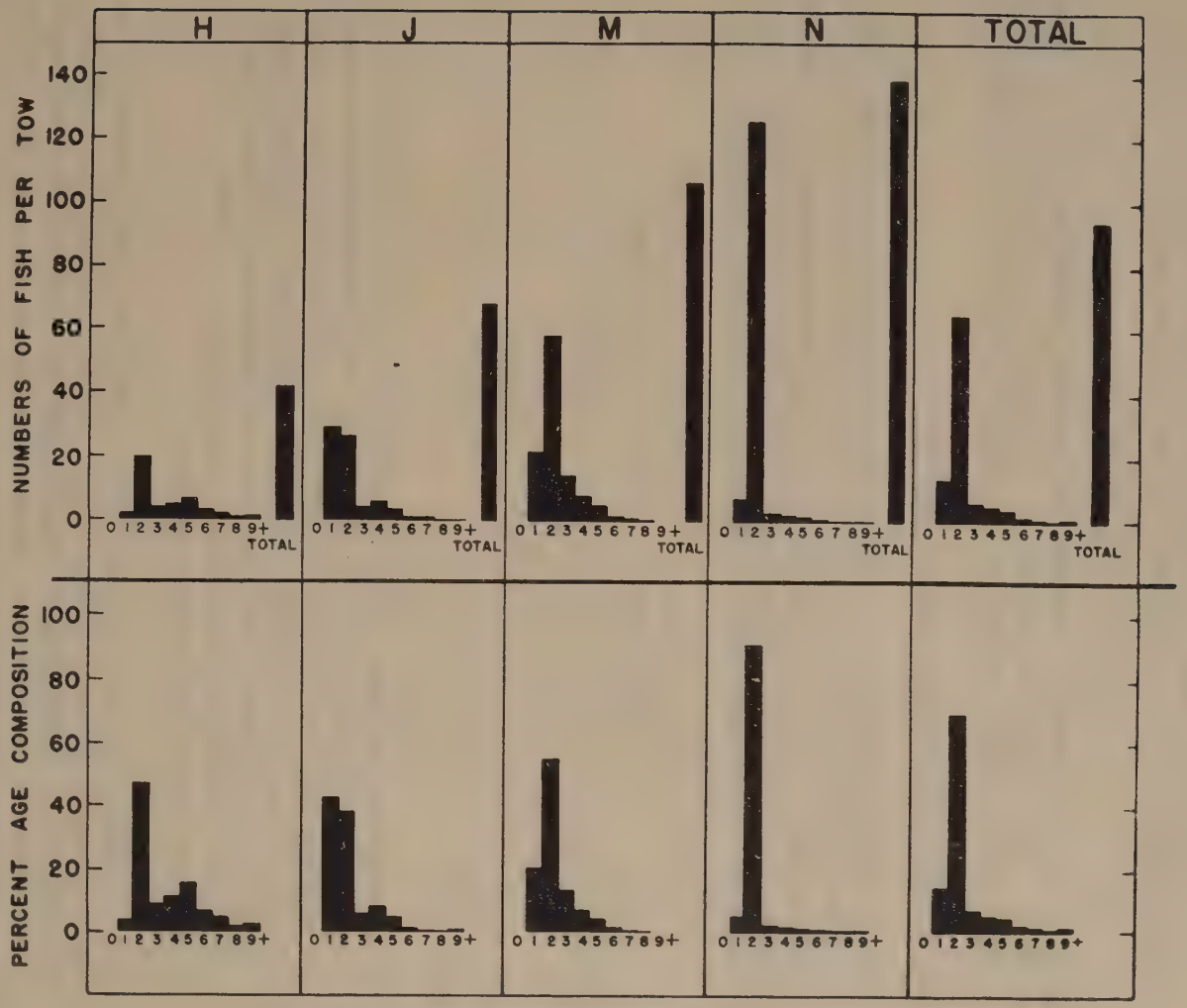

Figure 8.--Catch per tow and percentage age composition by subarea and total area, Spring, 1950.

Spring

The catch per tow (total and by ages) and the percentage age composition by subarea for 1950 (spring is shown in figure 8 and table A-2). The total catch per tow was greatest in subarea N, showing a shift from the summer distribution. Two-year-old fish dominated the catch as in the summer of 1950.

Because these subdivisions of the bank are based on commercial fishing concentrations and thus purely artificial boundaries, discussion of the distribution of different age fish will now be considered in the light of certain ecological conditions.

Abundance and Age Composition as Related to Depth

As stated in the introduction, sampling at census stations was stratified by 3 depth zones: 0-30, 31-60, and 61-150 fathoms. A preliminary analysis, however, revealed that the catch per tow dropped markedly in depths between 60 and 90 fathoms. For this reason the third depth zone was further divided into 2 zones. Thus, there are four zones used in the study of the relation of the distribution of haddock with depth. They are as follows:

Depth zones	Depth range in fathoms
I	0-30
II	31-60
III	61-90
IV	91-150

Summer

Figure 9 and table A-3 show the total and relative abundance of the different ages in the four depth zones for the years 1948, 1949, and 1950, as well as the 1949-1950 means. In all three years depth zone II yielded the most haddock followed in descending order by depth zones I, IV, and III The only exception was in 1948 when depth zone IV yielded a slightly greater catch per tow than depth zone I. In every year of the survey the zone between 61 and 90 fathoms showed a very much lower concentration of haddock than depths either above or below it.

The age composition of the catch also varies with depth. This is evident from figure 9, but is brought out more clearly in figure 10 where the catch per tow of each age is expressed as a percentage rather than numerically. It is clearly seen that the percentage of older fish increases with increasing depth from zone I and IV. This is best illustrated by the 1949-1950 means.

When the catch per tow is expressed in terms of weight rather than numbers we find that a considerable portion of the haddock stock occurred in deep water, at least during the times of these surveys.

To convert numbers of haddock to pounds the factors in table 6 were used.

Table 6.--Age-weight relationship of haddock in summer

Age of fish	0	1	2	3	4	5	6	7	8	9+
Mean weight	0.30	0.93	1.71	2.60	3.43	4.12	4.86	5.71	6.48	7.64

These factors are average weights of each age during summer months. For the purpose of studying the differential age distribution with depth the fish were divided into two groups according to age. The 4-year-olds and younger fish were placed in the first group while those more than 4-years old were placed in the second group. The abundance of these two age groups at the different depths is presented in table 7.

Table 7.--Depth distribution of young and old fish in summer

		0-4 years		5-9+ years		Total	
Year	Depth zone No.	Numbers per tow	Pounds per tow	Numbers per tow	Pounds per tow	Numbers per tow	Pounds per tow
1948	I	13.15	25.28	1.57	7.50	14.72	32.78
	II	64.53	91.09	0.69	3.25	64.68	94.34
	III	5.61	4.66	0.47	2.35	6.08	7.01
	IV	12.63	31.79	4.85	24.66	17.48	56.45
1949	I	116.34	122.78	1.87	8.65	117.61	131.43
	II	232.91	297.64	3.27	14.71	236.18	312.35
	III	1.09	2.82	0.38	1.82	1.47	4.64
	IV	12.78	37.94	7.88	39.92	20.66	77.86
1950	I	46.99	79.14	5.10	22.73	52.09	101.87
	II	94.62	112.97	1.45	6.88	96.07	119.85
	III	3.88	3.17	1.35	6.93	5.23	10.10
	IV	19.62	24.81	9.70	46.60	29.32	71.41
1949-1950	I	78.45	99.11	3.62	16.28	82.07	115.39
	II	163.11	200.17	2.36	10.83	165.47	211.00
	III	2.54	3.01	0.87	4.41	3.41	7.42
	IV	15.62	32.55	8.62	42.64	24.84	75.19

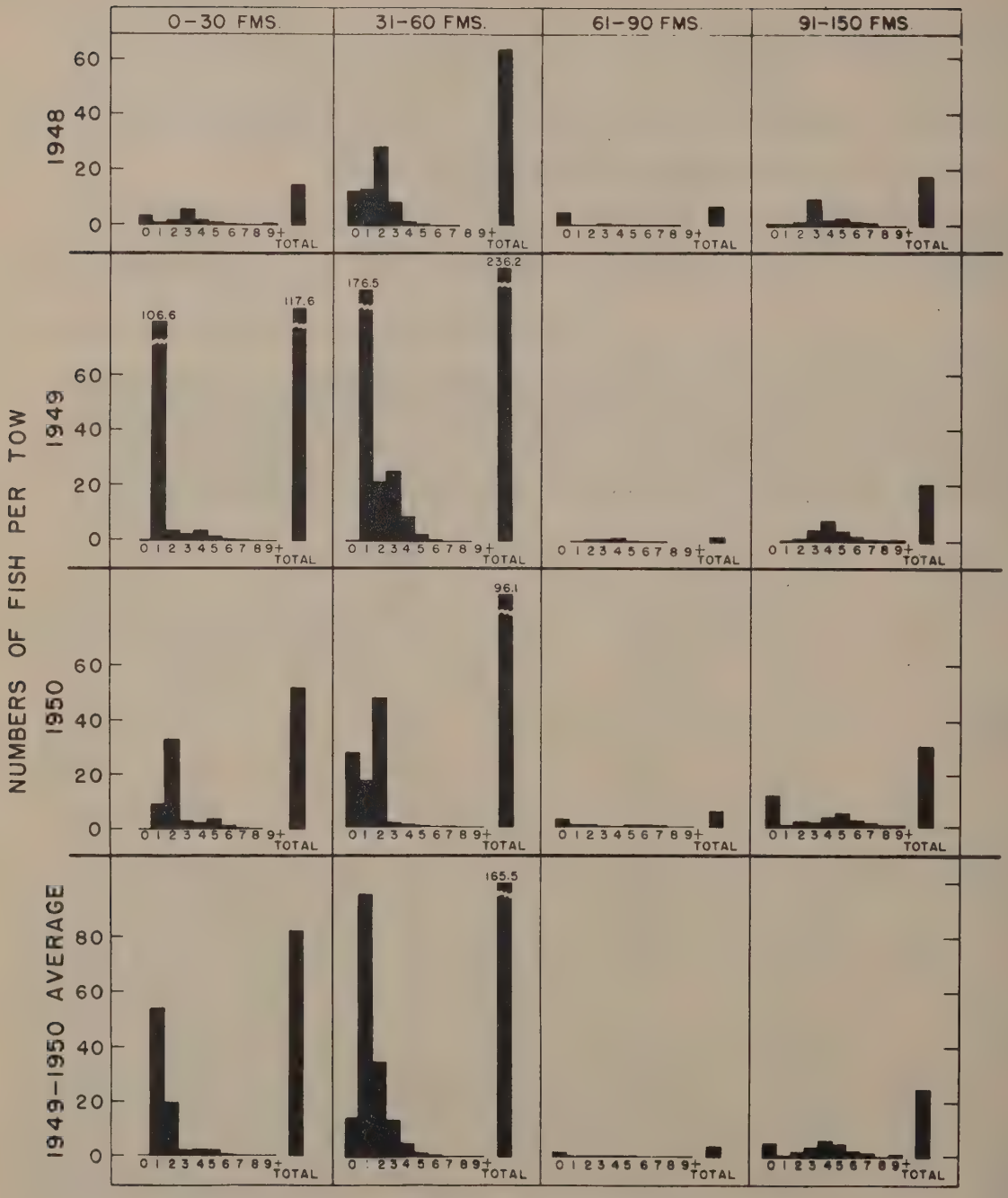

Figure 9.--Total catch per tow of individual ages by depth zone, Summer.

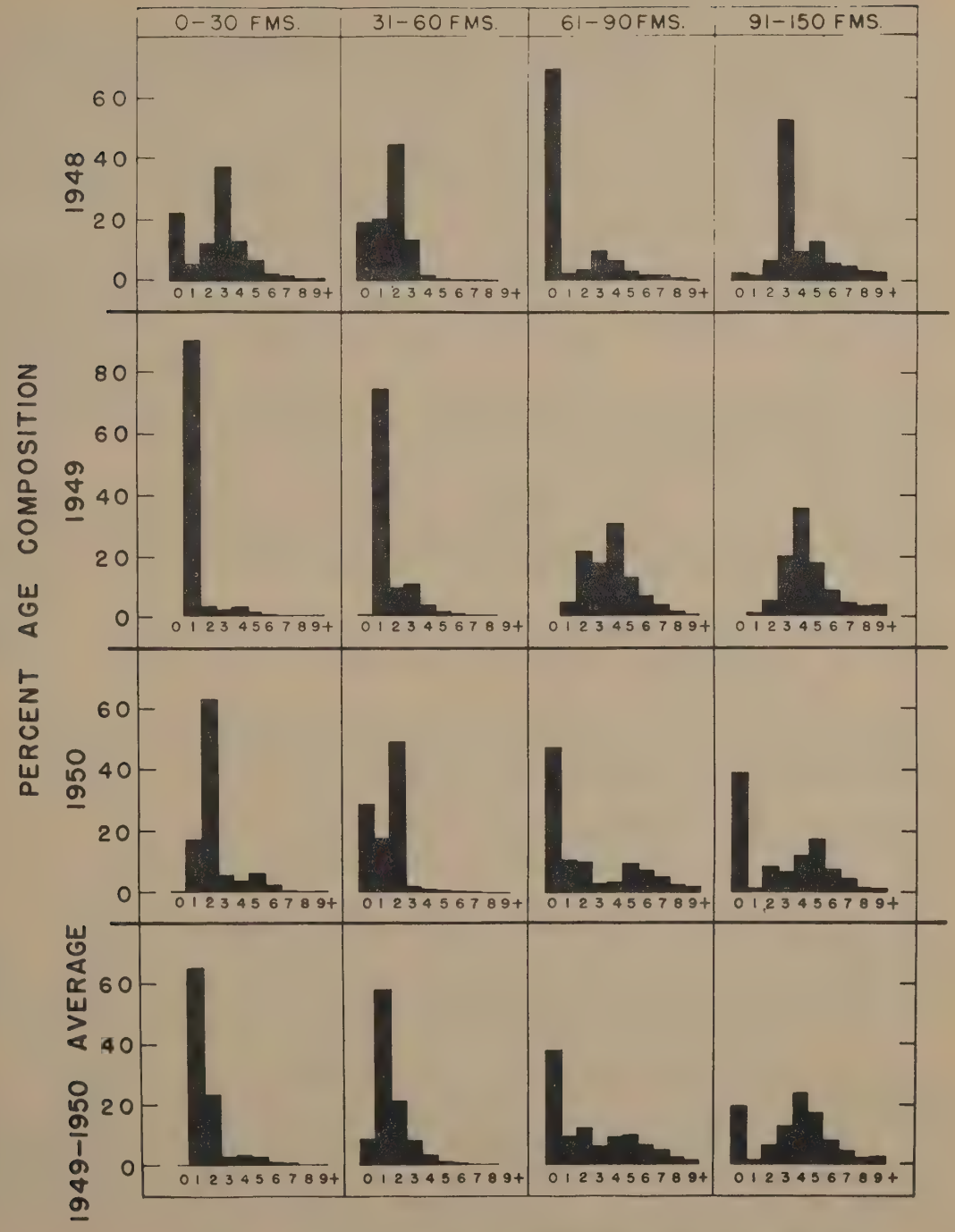

Figure 10.--Percentage age composition for each depth zone, Summer.

It is clear from these data that:

1. The total catch per tow (unsegregated year classes) was greatest in depth zone II and least in depth zone III whether expressed as numbers or as weight. This situation was found in each survey year.

2. The young fish (0-4 years) were most abundant in depth zone II and least abundant in zone III whether the catch per tow be expressed in numbers or in pounds. This situation was found in each survey year.

3. The older fish, on the other hand, showed the greatest abundance each year in depth zone IV when expressed in numbers or pounds per tow. In practically all cases the zone of least abundance of older fish was depth zone III.

4. In all years except 1948 and at all depths, the number per tow of 0-4-year-old fish was greater than the number per tow of 5-9+ year-old fish with the ratio diminishing with increasing depth.

5. In all years the weight per tow of 0-4-year-old fish was much greater than the weight per tow of 5-9+-year-old fish in depth zones I and II, practically equal in depth zone III and less in depth zone IV.

6. In no year was the weight per tow of 5-9+-year-old haddock in depth zone IV greater than the weight per tow of 0-4-year-old haddock in depth zone II.

In order to determine at which depth the most valuable quantity of haddock occurred the weight-per-tow data were further classified roughly according to market categories. The following four groups were made:

1. 0-2-year-old - representing haddock of unmarketable size. 1/
2. 3-4-year-olds - representing mostly "scrod haddock" which bring the lowest market price.
3. 5-9+-year-olds - representing "large haddock" which bring the highest market price.
4. 3-9+-year-olds - representing all marketable haddock. These fish are sold at a mixed price depending upon the proportions of scrod and large haddock.

The average weights per tow for each of these categories at each depth are presented in table 8.

1/ It must be kept in mind that this division of haddock into marketable and unmarketable groups according to age is an approximation based on average conditions during the spring and summer seasons. The age of haddock landed varies with the season of the year and with the relative abundance of the various year classes making up the population in the area fished (Schuck and Clark, 1951). An unmarketable haddock is defined as one weighing less than 1.5 pounds. In the average year this would include a small proportion of 3-year-old fish during the spring months and the majority of the 2-year-old fish during the summer.

In 1948, unmarketable haddock were most abundant in depth zone II. The weight per tow of "scrod haddock" was least in depth zone III and about evenly distributed in the other depth zones. The greatest weight per tow of 5-9+-year old and 3-9+-year-old haddock was in depth zone IV. The weight per tow of large haddock in depth zone IV almost equaled the weight per tow of all marketable haddock in depth zones I and II, and the weight per tow of all marketable fish, both scrod and large, was almost double that of other depths.

In 1949 the greatest weight per tow of unmarketable, marketable, and scrod haddock occurred in depth zone II. The greatest weight per tow of large haddock was obtained in depth zone IV. Considering that the market price ratio of large haddock to scrod haddock is roughly 3/2, the value of the catch in depth zone IV was considerably greater than that of the other zones.

Table 8.--Weights per tow of four age groups of haddock in four depth zones during summer of 1948, 1949, and 1950
(In pounds)

Depth zone, (in fathoms)	Summer 1948, in age group				Summer 1949, in age group				Summer 1950, in age group			
	0-2	3-4	5-9+	3-9+	0-2	3-4	5-9+	3-9+	0-2	3-4	5-9+	3-9+
0-30	6.14	20.58	7.50	28.08	105.04	17.87	8.64	26.51	64.84	14.24	22.73	36.97
31-60	65.27	24.78	3.23	28.01	201.04	73.96	14.71	88.67	105.02	7.94	6.88	14.82
61-90	1.80	2.86	2.36	5.22	0.61	2.22	1.83	4.05	2.13	1.04	6.94	7.98
91-150	2.28	29.49	24.65	54.14	2.16	35.79	39.93	75.72	7.94	16.88	46.65	63.53

In 1950 the separation of the various age categories of haddock was even more marked. The greatest weight per tow of unmarketable haddock was again obtained in depth zone II, while the weight per tow of 3-4, 5-9+ and 3-9+-year-old haddock was greatest in depth zone IV. The weight per tow of large haddock alone in depth zone IV was more than three times that of all marketable haddock in depth zone II.

It appears, then, that as far as the haddock fishery is concerned, it would have been both more profitable to the fishermen and more expedient from a conservation standpoint to have fished in depths greater than 90 fathoms during this period.

The effort of the commercial fleet during this period was concentrated in water shoaler than 60 fathoms (fig. 17). The reason the fishermen restricted their efforts to the shoaler water when there were available more pounds of large haddock in deep water is not immediately apparent. Perhaps they were unaware of the presence of these fish. If in fishing operations they gradually extended their drags from the productive depth zone II into deeper water they would be moving into the 61-90 fathom deep zone which was the least productive zone. It is possible, then, that depth zone III represented a barrier to the deeper, more productive areas.

Furthermore, the fact that this depth distribution is seasonal (see page 31) could also explain why the fishermen may not be aware of it.

The greater expense of fishing in deeper water must also be taken into consideration. Setting the gear in deep water is more difficult and hauling requires much more time. There is also the danger of tearing the net on the rough bottom in the lesser known depths.

The presence of a greater number of trash fish or a smaller number of other marketable species, however, does not appear to be a justifiable reason for avoiding deeper water as a further analysis of the Albatross III census data revealed that the proportions of marketable and unmarketable fish 2/ of other species did not fluctuate appreciably with depth.

The above study of depth relations is based on records for the bank as a whole. In the preceding section dealing with the variations of the catch in different subareas it was noted that subareas G and H consistently had the highest catch per tow and the highest percentage of older haddock (5 years). Correlating this with the fact that older haddock were more abundant in deeper water, it is interesting to note from fig. 11 and table 9 that the subareas yielding the greatest concentration of older haddock are the ones having the greatest area of water deeper than 90 fathoms.

2/ Whether a fish is marketable or not depends largely upon the amounts caught, the purpose of the trip, and where the fish are to be sold. For example, vessels fishing out of Boston concentrate their efforts on haddock and in the Georges Bank area while vessels fishing out of Gloucester fish primarily for redfish and in the Gulf of Maine. The Boston boats discard redfish, which are found only in depth zone IV, for there is little market for them in Boston, while the Gloucester fleet finds a market for both redfish and haddock.

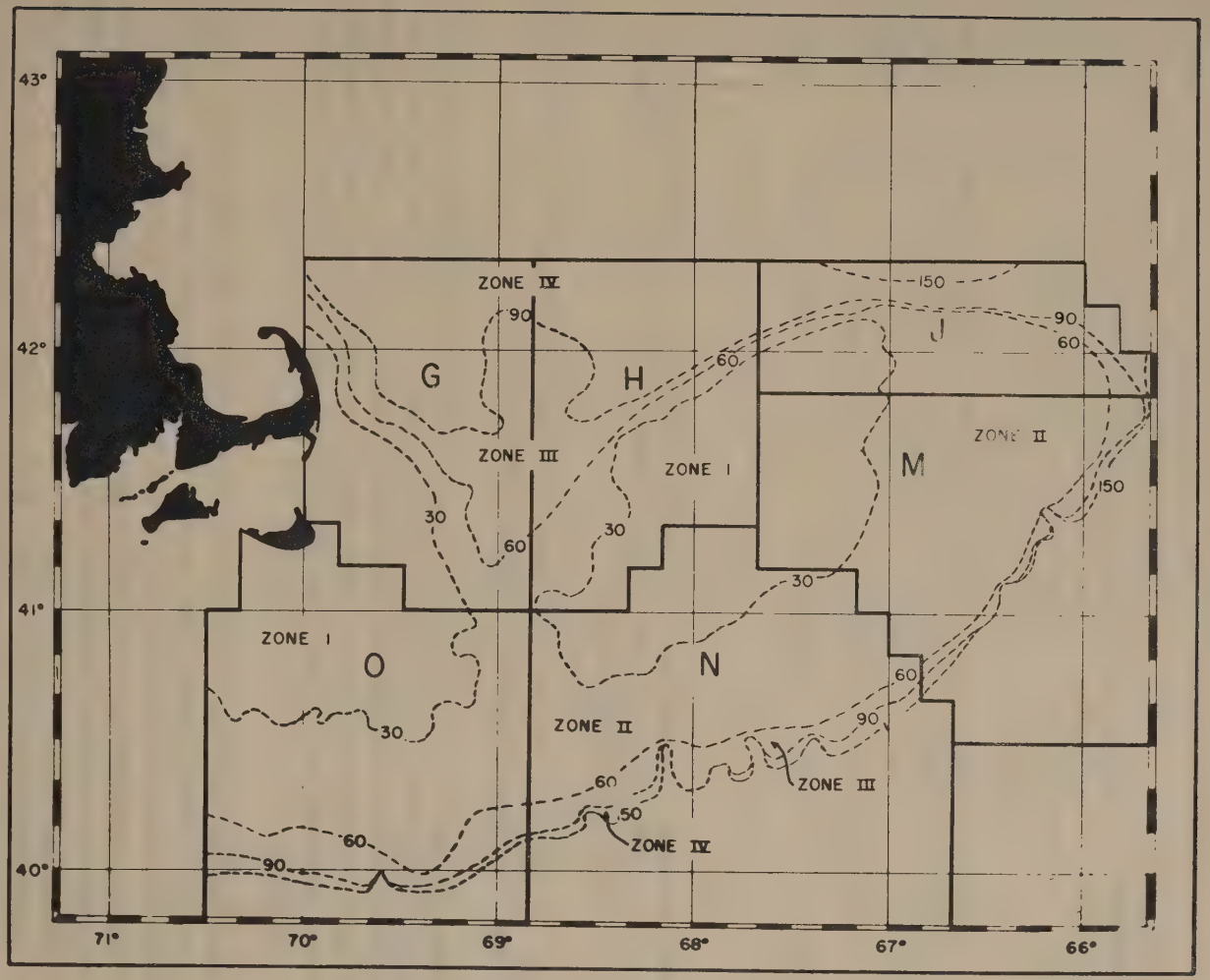

Figure 11.--Subareas and depth zones on Georges Bank.

Table 9.--Areal extent of each depth zone in each statistical subarea of Georges Bank (area in square miles)

Depth zone (in fathoms)	Statistical subarea						
	G	H	J	M	N	O	Total
0-30 fms.	964	1,211	405	795	1,050	1,980	6,405
31-60 fms.	578	506	851	2,044	2,160	2,520	8,659
61-90 fms.	788	518	158	199	491	278	2,432
91-150 fms.	1,215	1,249	701	83	218	60	3,526
Total	3,545	3,484	2,115	3,121	3,919	4,838	21,012

In subareas M, N, and O the area of water greater than 90 fathoms was negligible. Therefore, these subareas were omitted in the study of the regional aspects of the depth-age relationship.

The 1949 and 1950 data were averaged in terms of weight per tow by depth zone for the three other subareas and are presented in table 10. 3/

Comparing table 8 with table 10 it is seen that the weight per tow of each age group in each of the three subareas was in general similar to that for the whole bank. The weight per tow of large haddock (5-9+ years) was greatest and the weight per tow of discards (0-2 years) was least in depth zone IV in each subarea, except in subarea H where the weight per tow of 5-9+-year-old haddock was slightly less in depth zone IV than in depth zone I.

Regarding the sharp and consistently lower catch per tow of all ages of haddock in depth zone III, several causes could be postulated. The area bounded by the 60 and 90 fathom contour lines consists for the most part of a narrow band along the edge of the bank representing to the north a transition zone between the shallow bank water and the deeper water of the Gulf of Maine, and to the south and east a transition between the shallow bank water and deep water off the continental shelf. Because the gradient between the 60 and 90 fathom lines is greater than that above or below this zone, it was thought that possibly the efficiency of the otter trawl was affected by

3/ The catch per tow by depth zones for individual subareas are presented in tables A-4, A-5, A-6, A-7, and A-8 in the Appendix.

the slope. However, no average slope greater than 2 degrees was found to exist between contour lines. Furthermore, occasionally large catches of other species of fish have been made in this depth zone showing that if the haddock are in this depth zone they can be caught with the gear used.

The only other factor which appears to differentiate this zone from the shallower bank water and the deeper Gulf of Maine and oceanic water is the character of the bottom sediments. The bottom sediment distribution and its possible relationship to the distribution of haddock will be discussed in a later section.

Table 10.--Mean weight per tow by depth zones for subareas G, H, and J, summer, 1949-1950 average

Subarea	Depth zone No.	Age group 0-2	3-4	5-9+	3-9+	Total
G	I	24.42	63.71	32.59	96.10	120.52
	II	11.52	2.38	1.71	4.09	15.61
	III	3.44	4.28	7.32	11.60	15.04
	IV	6.86	27.86	48.92	76.78	83.64
H	I	96.50	34.10	55.05	89.15	184.65
	II	23.17	6.23	9.54	15.77	35.95
	III	3.19	1.92	11.98	13.90	17.09
	IV	1.06	21.33	46.21	67.54	68.60
J	I	233.50	24.57	3.24	27.81	261.31
	II	274.94	227.16	16.90	224.06	519.00
	III	0.90	0.03	15.69	15.72	16.62
	IV	5.21	44.67	36.79	81.46	86.67

Spring

Figure 12 shows the abundance in terms of numbers and percentages of the various age fish in the four depth zones during the spring of 1950.

At this season the total abundance of haddock decreased with increasing depth with 2-year-old fish dominating the catches in depth zones I and II and 3-year-old fish dominating the catches in depth zones III and IV. Although, as mentioned previously, these figures are based on a limited coverage of the bank, it is seen that

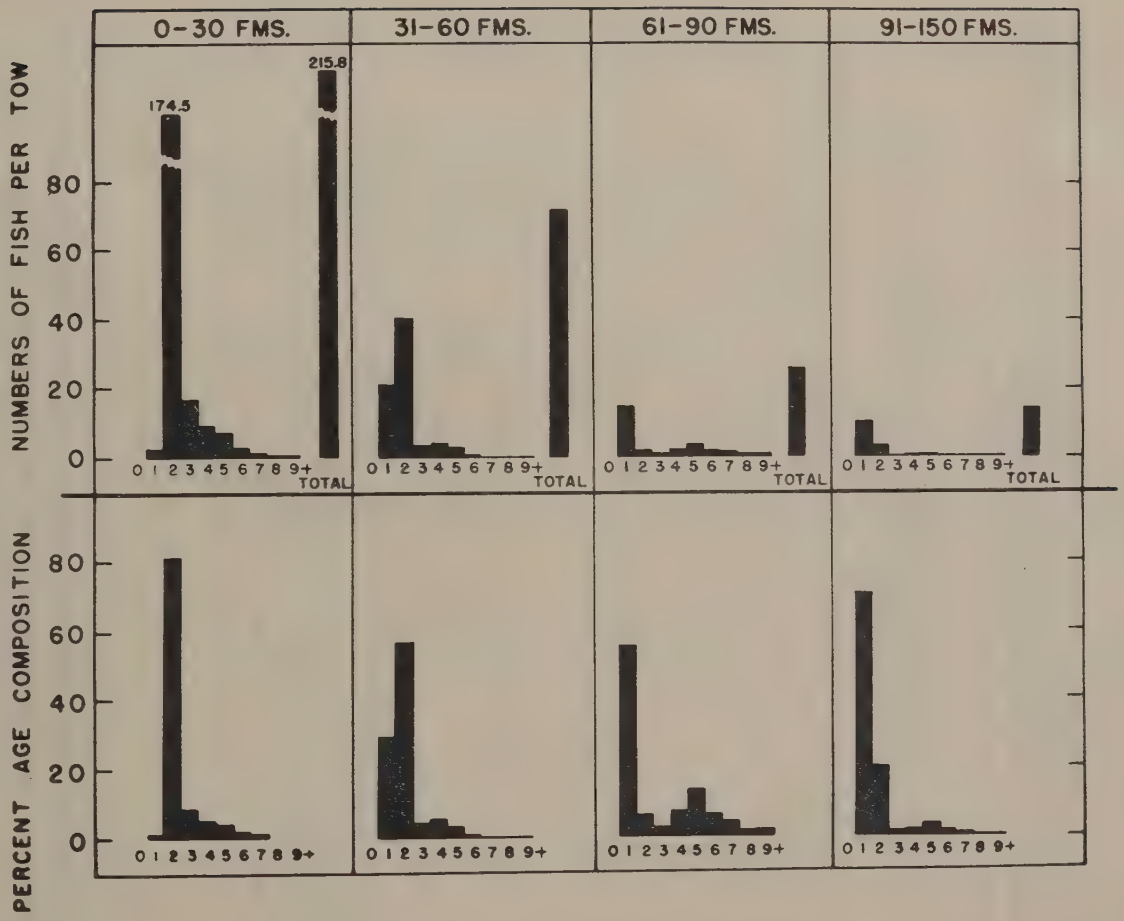

Figure 12.--Catch per tow and percentage age composition for each depth zone, Spring, 1950.

during this season there was no longer a greater proportion of older haddock (5+years) in deeper water. The catch per tow in depth zone III, which during the summer months was negligible, was now considerably greater than that in depth zone IV. In general, there appeared to be less segregation of age groups, although the majority of younger fish (1-3 years) were found in depths less than 60 fathoms. The age composition by depths is more clearly shown in the percentage age composition of the total catch. The greatest percentage of older fish (5+years) occurred in tows made in depth zone III.

To convert numbers of haddock to pounds of haddock during this season the factors in table 11 were used. From these factors the weight per tow was determined for the four age groups as was done with the summer data. The weight and catch per tow for these four age groups are shown in table 12.

Table 11.--Age - weight relationship of haddock in spring

Age	1	2	3	4	5	6	7	8	9+
Weight	0.5	1.1	2.3	3.2	3.9	4.7	5.5	6.2	7.0

Table 12.--Age group distribution in the four depth zones (spring 1950)

Depth zone (in fathoms)	Spring (1950) age group			
	1-2	3-4	5-9+	3-9+
	Number per tow			
0-30 fms.	176.82	26.08	12.86	38.94
31-60 fms.	61.46	7.03	3.20	10.23
61-90 fms.	16.07	2.61	7.10	9.71
91-150 fms.	12.51	0.42	0.94	1.36
	Weight per tow			
0-30 fms.	193.09	68.36	56.99	125.35
31-60 fms.	55.07	19.70	13.61	33.31
61-90 fms.	9.09	7.69	30.20	37.89
91-150 fms.	7.92	1.21	4.60	5.81

The depth distribution during the spring was markedly different from the distribution during the summer months. The catch per tow and weights per tow of unmarketable fish (1-2 years) and scrod (3-4 years) decreased with increasing depth. The catch per tow of all marketable haddock (3-9+ years) decreased with increasing depth, but was practically uniform between 31 and 90 fathoms. The weight per tow of all marketable haddock, however, was slightly greater in depth zone III than in depth zone II. The catch per tow and weight per tow of large haddock (5-9+ years) was greatest in depth zone I, followed in descending order by depth zones III, II, and IV. Depth zone IV, where in summer the greatest concentration of large haddock were found, was the least productive area for all age groups.

It appears then that at this season it would have been most profitable to fish in shoal water (0-30 fathoms), but also at this depth the greatest destruction of immature fish would occur. From the conservation standpoint, depth zone III would be the most desirable fishing area. However, a much more thorough coverage of the bank at this season is needed to substantiate these conclusions.

This inshore movement of older fish during the spring is evidenced in the landings of the commercial fleet which show a marked increase in the percentage of older haddock at this season. Such a movement is associated with spawning activity and has also been found to occur in European stocks of haddock (Thompson 1929b).

Although there is a slight variation from year to year, the spawning season for Georges Bank haddock is mainly from February through April (Bigelow and Welsh, 1942, Walford 1938). These spawning dates are further substantiated by the fact that large numbers of ripe fish were taken during the spring cruise of the Albatross III. Thus the above data for the spring represents conditions existing during the spawning season.

The age at maturity (age at which spawning occurs) varies considerably with location. Bigelow and Welsh (1925) give 4-5 years as the age at maturity for haddock in the Gulf of Maine area near Cape Ann. More recent data obtained on the Albatross III and commercial vessels during March of 1949 and 1950 indicate that the age at maturity for Georges Bank haddock is considerably earlier than this and is different for males and females. The following table (table 13) gives the age at maturity for haddock on Georges Bank, Browns Bank, the Newfoundland Banks, and the North Sea.

The age at maturity of Georges Bank haddock is very similar to that for the North Sea, while Bigelow's figures for the Gulf of Maine coincide with Albatross III observations on Browns Bank and with Thompson's figures for Newfoundland and Iceland, the haddock from the latter area maturing at 4-6 years (Thompson 1929A).4/

4/ There exists slight evidence to the effect that the age at first maturity varies between year classes and that first maturity occurs in the larger fish of a certain year class. (Hansen 1949).

Table 13.--Age at maturity for haddock in various geographic areas

Haddock	Percentage of mature fish at age--					Location
	2	3	4	5	6	
Males	40	98	100	--	--	Georges Bank
Females	0	77	100	--	--	
Males	0	0	100	100	--	Browns Bank
Females	0	0	60	100	--	
Males	60	95	99	100	100	North Sea,
Females	10	75	95	99	100	(Raitt 1936A)
Males & Females	0	15.5	44.5	95.0	100	Newfoundland (Thompson 1939)

The division of haddock into 1-2 year and 3-9+ year age groups roughly separates these haddock into immature and mature or spawning fish. Thus the age-depth distribution found on the basis of this grouping results from a spawning migration.

It may be stated, then, that the mature haddock seek shoaler water during the spawning season than during the summer months. That depth is a factor of prime importance in the determination of spawning location is well known and the depth limits of spawning are similar for the various banks. Bigelow and Welsh (1929) state that the important spawning grounds in the Gulf of Maine are all shoaler than 75 fathoms, with 15 to 20 fathoms as the upper limit and 100 fathoms as the lower limit of any considerable spawning. They also note that no haddock spawn in the deep basin of the Gulf of Maine (depth zone IV). Schmidt (1909) and Raitt (1936), using data based on egg distribution, give 27-109 fathoms as the depth range of spawning for European haddock. Thompson (1929A) from observations on egg distribution gives 44-82 fathoms as the range of spawning depth of Icelandic haddock. Needler (1930) from information based on the commercial catch, states that in early spring haddock are caught in abundance in water less than 25 fathoms, and as summer proceeds these fish withdraw to somewhat deeper water. Thompson (1929B) demonstrated that North Sea haddock congregate into spawning and feeding concentrations during the spring and summer months and the depth distribution of these two concentrations is seen to be similar to the spring and summer depth distribution observed on Georges Bank.

It is apparent then that it is a spawning migration to shoaler water that is the cause of the change in the depth distribution of haddock during the spring. The depth distribution of Georges Bank haddock during both spring and summer is similar to

that of haddock in other regions, especially to that of the North Sea. The observation that older fish generally seek deeper water and appear to migrate more than younger fish is in agreement with findings in other areas (Thompson 1943).

Abundance and Age Composition as Related to Bottom Type

During Albatross III cruises more than 250 bottom samples were obtained by use of "scoop-fish" bottom sampler attached to the nose of a bathythermograph. This sampler worked successfully, obtaining approximately a 50-gram sample over mud, sand, and gravel bottoms, while over harder bottoms only chips were obtained. The bottom samples thus taken were classified according to the four size categories given in the Hydrographic Manual (Adams 1942).

When these data were plotted and lines of demarcation drawn, it became apparent that due to the insufficient number of samples in certain areas and the inability of the gear used to obtain a reliable sample of particles larger than 6.0 mm. that the following consolidation of the data was advisable:

Sediment	Description
Sand	Sand and stony sediments with particle diameters greater than 0.1 mm.
Mud	Mud and sand-mud sediments with particle diameters mostly less than 0.1 mm.

This consolidation was verified by the fact that the distribution of haddock was similar over sand and stony bottoms and over mud and sand-mud bottoms. A chart (fig. 13) was prepared according to this classification of Albatross III samples and to data given in Coast and Geodetic Survey Charts 1106A and 1107A.

Summer

Figure 14 and table A-3 show the total and the relative abundance of the different ages of haddock over sand and mud for the years 1948, 1949, 1950, and the 1949-1950 means.5/ The total catch per tow was consistently greater over sand than over mud bottoms and this greater abundance was in large part due to the greater numbers of younger fish.

In table 14 the catch per tow and weight per tow data by bottom type is grouped into unmarketable haddock, scrod, large haddock, and total marketable haddock, as was done with the catch by depth zones.

5/ The catch per tow by bottom type for the individual subareas are tabulated in tables A-4, A-5, A-6, A-7, A-8, and A-9 in the appendix.

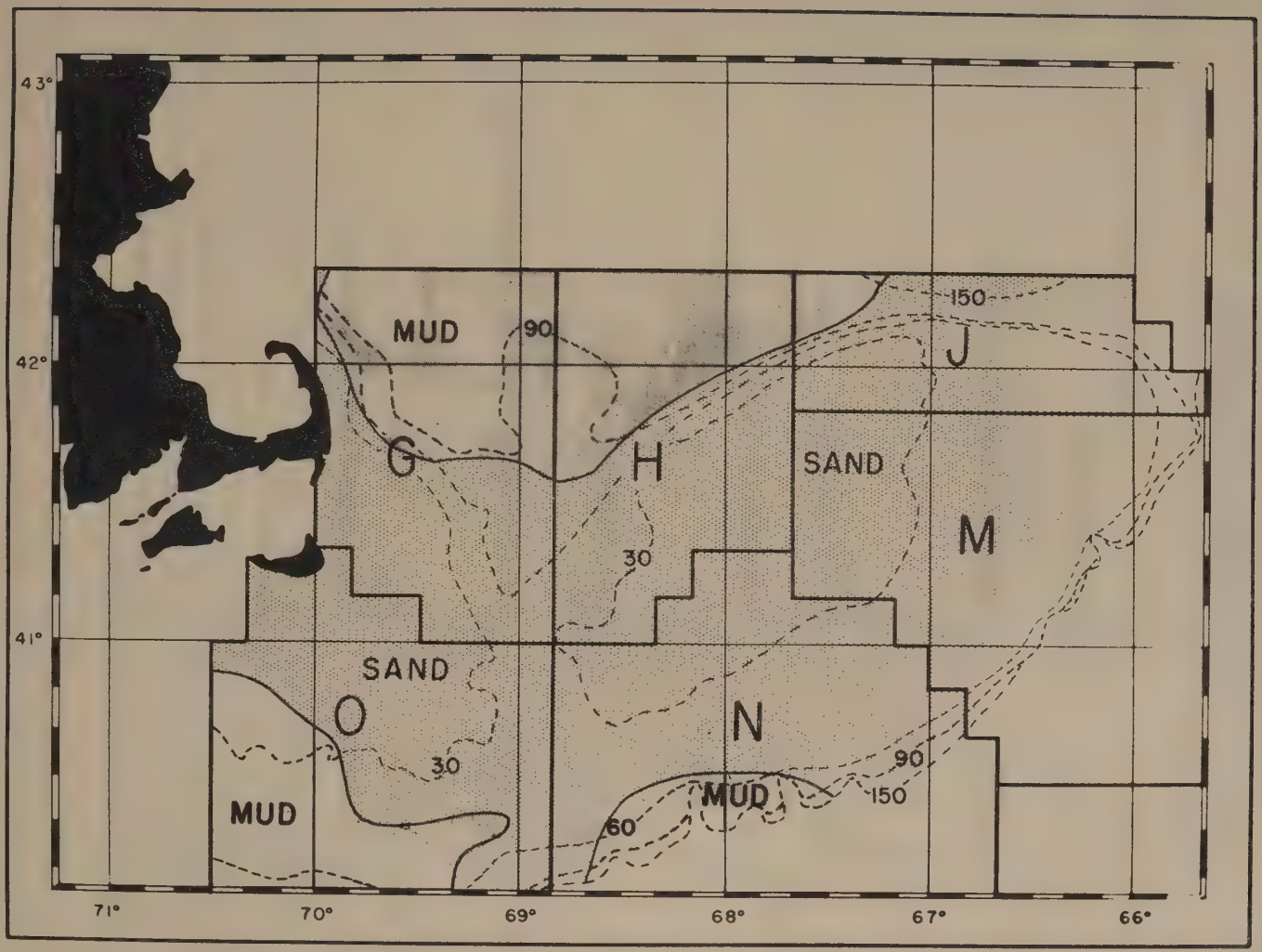

Figure 13.--Bottom sediment distribution on Georges Bank.

Table 14.--Age group distribution by bottom type in summer

Year	Bottom type	Age group 0-2	3-4	5-9+	3-9+
				Numbers per tow	
1948	Sand	37.61	8.51	1.04	9.55
	Mud	1.83	7.70	3.41	11.11
1949	Sand	137.88	23.95	3.33	27.28
	Mud	38.39	4.89	4.46	9.35
1950	Sand	84.80	4.15	3.71	7.86
	Mud	15.71	1.56	3.69	5.25
1949-1950 Mean	Sand	105.44	14.27	3.50	17.77
	Mud	26.56	3.15	4.05	7.20
				Pounds per tow	
1948	Sand	44.05	23.24	4.97	28.21
	Mud	1.63	20.94	17.35	38.29
1949	Sand	138.38	68.34	15.62	83.96
	Mud	39.68	15.76	22.26	38.02
1950	Sand	110.11	12.38	17.12	29.50
	Mud	14.18	4.83	17.95	22.78
1949-1950 Mean	Sand	113.45	40.98	16.26	57.24
	Mud	25.36	10.05	19.97	30.02

This grouping shows that the catch per tow and weight per tow of unmarketable haddock and scrod was greatest over sand. The catch per tow and weight per tow of all marketable haddock (3-9+ years) was greatest over sand except in 1948. The catch per tow and weight per tow of older haddock (5-9+ years) was with one exception slightly greater over mud than over sand bottoms. Although older haddock occurred in greater numbers over mud than over sand, the separation is not as marked as that corresponding to depth.

In order to determine whether depth or bottom type was the controlling factor in the distribution of older haddock, an analysis of variance was made on the abundance data shown in table 15.

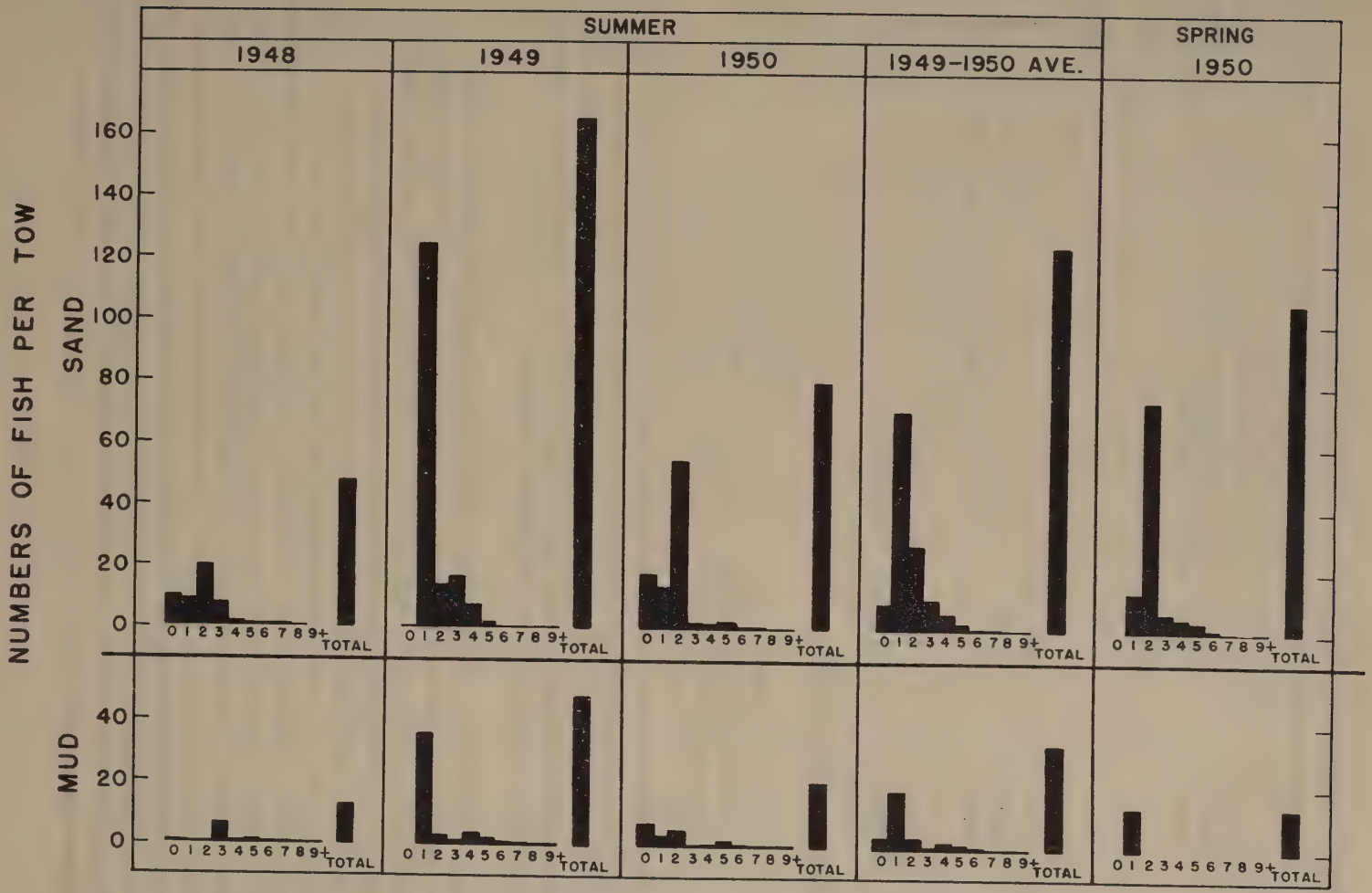

Figure 14.--Total catch per tow and catch per tow of individual ages by ages by bottom type, Summer and Spring.

Table 15.--Catch per tow of 5-9+ year-old haddock by depth and bottom type during the summer of 1948, 1949, and 1950

Year	Bottom type	Depth zones I 0-30 fms.	II 31-60 fms	III 61-90 fms.	IV 91-150 fms.
1948	Sand	2.03	0.80	0.80	0.68
	Mud	0	0	0.06	7.14
1949	Sand	1.92	10.48	0.55	5.22
	Mud	0	0	0.29	9.41
1950	Sand	5.92	1.71	1.38	11.47
	Mud	2.23	0	1.32	8.27

The variance ratio values were as follows:

Difference between years. F = 1.79 (not significant).
Difference between depths. F = 5.51 (significant).
Difference between bottoms. F = 1.01 (not significant).

Thus it is seen that the summer distribution of older haddock was consistent during the three years, and that depth rather than bottom type was the controlling factor in this distribution. This is as expected for the only locations in which relatively large numbers of older haddock were caught over mud bottom were locations in which the depth was greater than 90 fathoms (subareas G and H).

It appears, however, that the character of the bottom sediments does serve to differentiate the 61-90 fathom depth zone from the shallower bank water and the deeper Gulf of Maine and oceanic water. More detailed analyses by Stetson (1938) and Northrop (1951) show that there is a certain uniformity in the arrangement of bottom sediments of the continental shelf when they are considered by regions. Profile lines from the glaciated section (New England and north), irrespective of slope, have certain characteristics in common They all start with a zone of relatively fine sand near shore, followed by a belt of coarse sands and gravel, which in turn are succeeded by a zone of sand and gravel plus varying amounts of silts and clays lying on the middle and outer parts of the shelf. Lines crossing the break in the continental slope show a definite coarsening of texture there. All the traverses show a remarkable correspondence in the depth of water at which these zones occur, which is obviously the controlling factor as the lines are of varying length. Consequently, on lines from the Gulf of Maine where deep water is soon reached, the succession of zones is

necessarily compressed into a few miles. Over Georges Bank, which can be considered as an extension of the continental shelf, the regional distribution is similar to that of other sections of the shelf, having a like arrangement of bottom sediments in which depth is the controlling factor. Although the zonation over the bank has a similar sequence and depth limitations, the width of certain zones is greatly extended.

Figure 15 represents diagramatically typical profiles across various sections of the continental shelf and Georges Bank.

Apparently then the main factor differentiating the 61-90 fathom depth zone from the others is the lack of silt in the bottom sediments. Although obviously the silt in itself is not the direct cause for the scarcity of haddock, it is an indication of stronger current action. Such current action not only prevents the deposition of fine bottom sediments, but would also prevent the accumulation of detritus which serves directly or indirectly as food for the haddock Considering that the search for food, other than at periods of spawning, is the primary cause for the movements of bottom living fish, this could be a possible explanation for the scarcity of haddock in depth zone III during the summer months.

Spring

From figure 14 it is seen that during the spring of 1950 only 1-year-old fish were caught over mud bottom. The catch per tow and weight per tow data when grouped into unmarketable, scrod, marketable, and large haddock as shown in table 16 is again comparable to the depth distribution during this season (see table 12). The majority of the fish were concentrated in shoaler water and were consequently found over sand bottom.

A relatively high concentration of older haddock were found in depth zone III during the spring while in summer there was a scarcity of haddock in this region, theoretically accounted for by the lack of food at this depth. This reasoning still appears valid for there exists good evidence that haddock cease feeding during the spawning season. (Vladykov and Homans, 1935; Bigelow and Welsh, 1925; Needler 1930)

Comparison of Census and Commercial Data

In order to verify the age distribution of haddock as determined from the census data, a comparison was made with the catch of the commercial fleet on Georges Bank during July and August, 1949 and 1950, and April 1950. The method used in analyzing the commercial catch was as follows:

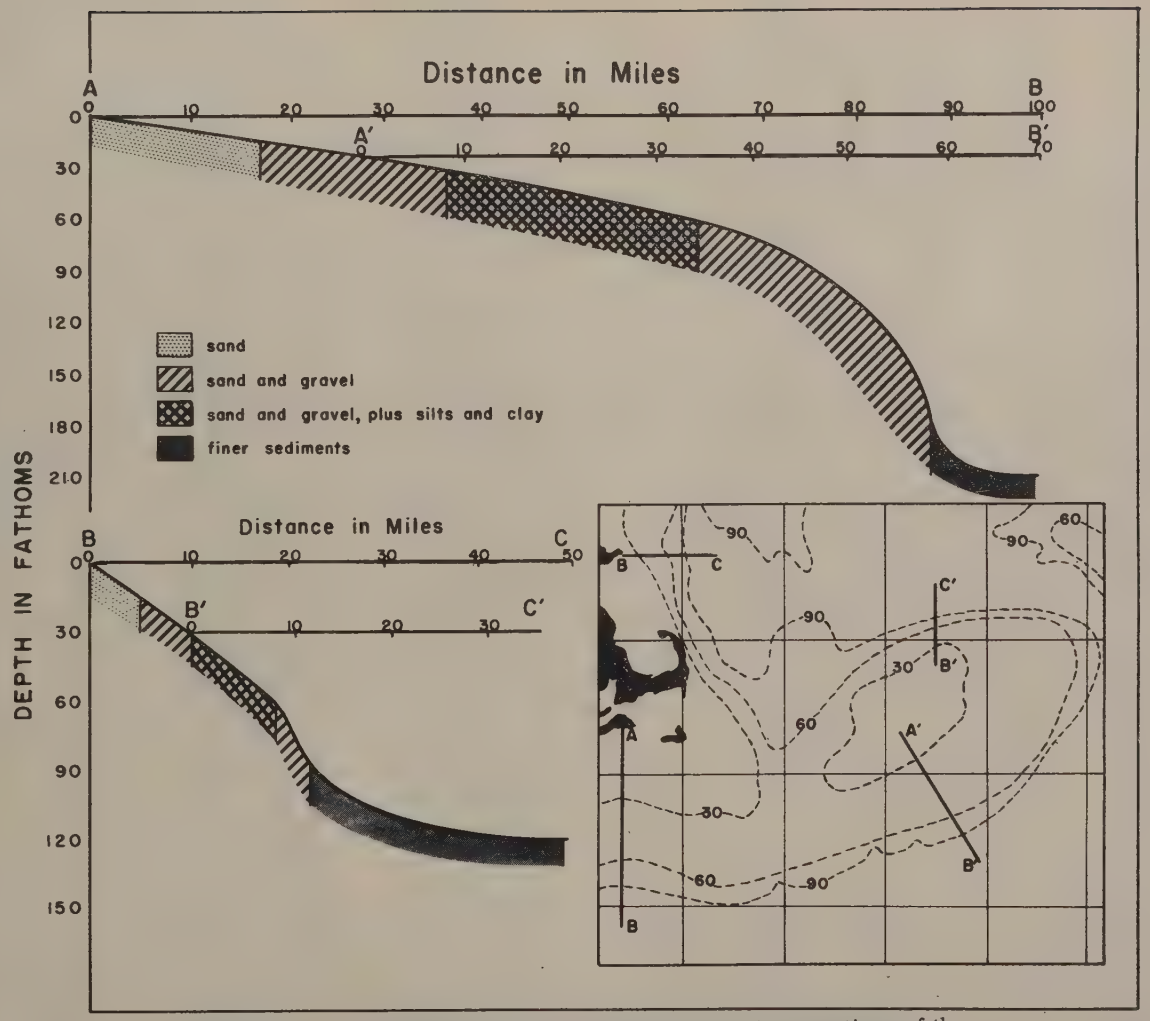

Figure 15.--Distribution of bottom sediments at various sections of the continental shelf and Georges Bank.

1. The weight of scrod and haddock and the effort in terms of days fished by subarea were obtained for the periods of concern from the catch records of the commercial fleet.

2. From the average weight of scrod and haddock during these periods these weights were converted to numbers of scrod and haddock.

3. These numbers of scrod and haddock were then allocated to their respective age groups from age readings of scale samples obtained from the landings of a random selection of boats.

4. The catch per day of each age was computed as percentages of the total catch in order to facilitate comparison with the data for census cruises.

Table 16.--Age group distribution of haddock over bottom during the spring

Type of bottom	Age group				
	1-2	3-4	5-9+	3-9+	Total
			Number per tow		
Sand	87.39	11.97	6.81	18.78	106.16
Mud	13.85	0	0	0	13.85
			Weight per tow		
Sand	88.32	32.18	30.26	62.44	150.76
Mud	6.93	0	0	0	6.93

Because the commercial fleet tended to concentrate in certain areas it was further necessary to weight the census data according to the effort expended by the commercial fleet and to exclude data outside the area fished by the fleet. This effort in terms of days fished and percentage of the total days fished by subarea is given in table 17.

Table 17 --Effort of the commercial fleet in terms of days fished per month and percentage

Date	Fishing Effort	Subarea					Total
		H	J	M	G	O	
1949 July-Aug.	Days fished	-	139.7	44.7	11.6	-	196.0
	Percentage all fishing	-	71.5	22.6	5.9	-	100.0
1950 July-Aug.	Days fished	-	268.2	56.3	4.2	5.0	333.7
	Percentage all fishing	-	80 4	16.8	1.3	1.5	100.0
1950 April	Days fished	9.2	29.4	9.6	-	-	48.2
	Percentage all fishing	19.1	61.0	19.9	-	-	100.0

It is seen that the commercial fleet concentrated its fishing to a very restricted portion of the bank with the maximum effort in both summer and spring being expended in subarea J. The weighted catch per tow and percentage age-composition of the census data and the catch per day and percentage age-composition of the commercial fleet is presented in table 18.

Table 18.--Comparison of age composition as determined from Albatross III data and commercial fleet samples

Item	Age group								Total
	2	3	4	5	6	7	8	9	
				Albatross III - 1949 July - August					
Catch per tow	42.37	57.07	20.20	3.43	0.80	0.40	0.18	0.16	124.61
Percent	34.00	45.80	16.21	2.75	0.64	0.32	0.15	0.13	100.0
					Commercial				
Catch per day	2488.1	3620.6	1290.4	236.8	88.0	47.1	28.9	21.3	7821.2
Percent	31.8	46.3	16.5	3.0	1.1	0.6	0.4	0.3	100.0
				Albatross III - 1950 July - August					
Catch per tow	74.48	4.12	4.41	3.50	0.97	0.37	0.12	0.10	88.07
Percent	84.57	4.68	5.01	3.97	1.10	0.42	0.14	0.11	100.0
					Commercial				
Catch per day	7794.9	995.1	720.3	345.0	100.9	43.4	18.9	18.6	2242.2
Percent	77.7	9.9	7.2	3.4	1.0	0.4	0.2	0.2	100.0
				Albatross III - 1950 April					
Catch per tow	30.99	5.75	5.52	3.97	1.16	0.56	0.17	0.24	48.36
Percent I	64.08	11.89	11.42	8.21	2.90	1.15	0.35	0.50	100.0
Percent II	-	-	47.5	34.1	10.0	4.8	1.5	2.1	100.0
					Commercial				
Catch per day	161.5	668.2	1203.3	923.2	306.4	163.4	19.3	104.7	3610.0
Percent I	4.5	18.4	33.4	25.5	8.5	4.5	2.3	2.9	100.0
Percent II	-	-	44.2	33.9	11.3	6.0	0.7	3.9	100.0

NOTE.--Two groupings (I and II) were made of data collected in spring by the Albatross III and by the commercial fleet to show differences and similarities in age composition of the samples.

In the summer months only 2-year and older haddock are tabulated. The reason for this is that the commercial boats which used gear having approximately a 3-inch mesh cod end did not sample zero and one-year-old fish adequately. Fish of this size that were retained in the net were discarded at sea and hence not included in the catch statistics. During the spring months still older fish are discarded including most of the 2-year-olds and a portion of the 3-year-olds. This increase in the culling age during the spawning season is due in part to the greater availability of older haddock in the area fished by the commercial boats and in part to the fact that a fish of a given age is smaller in the spring when the "haddock year" begins than in the summer. This increase in the catch of older haddock during the spring is evidenced by the landings of the commercial fleet over a number of years and is due to the migration of older fish into shoaler water as shown above. Thus, in the age group data shown in table 18 and figure 16, two groupings were made of the spring data in order to demonstrate the differences and similarities in the age composition as determined from commercial and census figures.

The age composition of the commercial and census data are similar during July and August of 1949 and 1950 for all ages and during April of 1950 when only 4-year-old and older fish are considered. The above comparison greatly attests to the reliability of the census data and its value in population studies when account is taken of the fact that these census data are based on a comparatively few completely random samples compared with that of the effort expended by the commercial fleet, which effort is necessarily biased in that it is concentrated on certain age groups and restricted areas.

Mortalities based on such a limited sampling of a population are necessarily at best rough approximations, but it is interesting to note that the mortalities determined from the weighted census data and commercial data for July and August of 1949 and 1950 are quite similar. These mortalities are given in table 19 and it is seen that the mortality for all ages appear exceptionally high which lends credence to similar figures determined from census data based on all subareas as shown in table 2.

Mortalities determined from census data for the period of July and August of 1949 to April of 1950 were consistently lower for all ages than those determined for the longer period of July and August of 1949 to July and August of 1950. However, similar figures based on commercial data give negative values for 5 year and older haddock for the 9 month period. These negative results are due largely to the migration of older fish during the spawning season from deep-water areas little fished by the commercial fleet into shoaler water where the greatest effort of the commercial fleet is expended.

The average mortality rates determined from the yearly abundance data of the commercial fleet obtained over a 20-year period show wide fluctuations throughout the

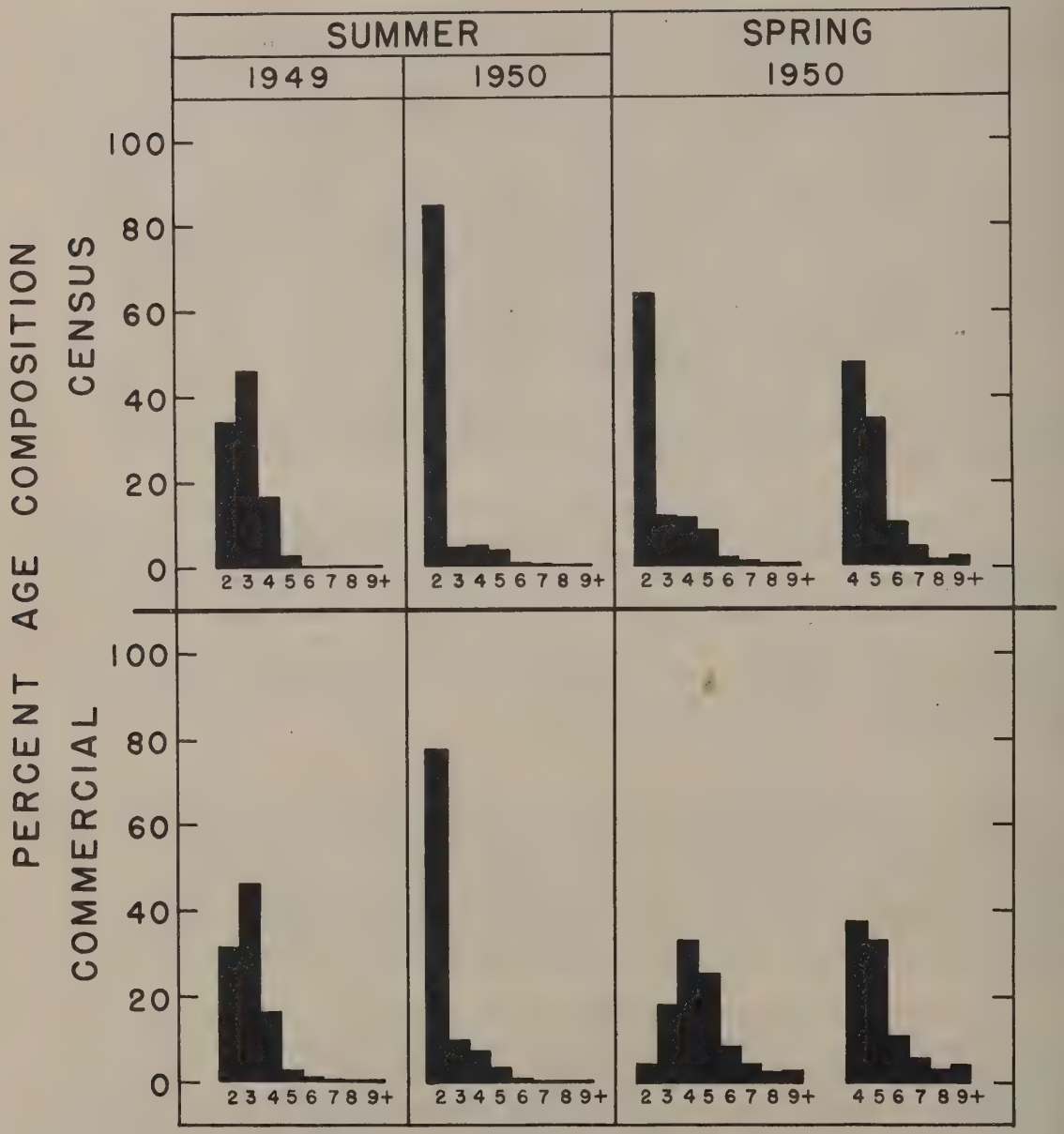

Figure 16.--Percentage age composition of commercial and census data during July and August 1950, and April 1950.

Table 19.--Mortality (percentage) based on commercial and weighted census data

Date	Source of data	Age group 2	3	4	5	6	7
1949, July & Aug. to 1950, July & Aug.	FWS Census	90.3	92.3	82.9	71.7	53.8	70.0
1949, July & Aug. to 1950, July & Aug.	Commercial fleet	60.0	80.1	73.3	57.4	50.7	59.9
1949, July & Aug. to 1950, April	FWS Census	86.4	90.3	80.3	66.2	30.0	57.5
1949, July & Aug. to 1950, April	Commercial fleet	73.1	66.8	27.7	---	---	---

years and in general a marked increase in the mortality of older haddock. To explain this, it had been assumed that the older haddock were fished more intensively. The census data, however, now show that the indicated increase in mortality with increasing age is probably fallacious and is due to the decrease in availability with increasing age caused by the migration of older fish to deeper, less fished regions.

From statistics obtained from commercial-catch records giving the number of days fished in each unit area during trips which were devoted primarily to catching haddock, it has been possible to make up concentration charts showing where the major effort was expended during July and August of 1949 and 1950. The following units of effort in terms of days fished were chosen in the construction of these charts:

Designation	Number of days fished per month
Very heavy	45-60
Heavy	30-45
Medium	15-30
Light	1-15

From census data for similar periods charts were constructed showing the distribution of 1-2, 3-4, 5-9+, and 3-9+-year-old fish representing unmarketable haddock, scrod haddock, large haddock, and all marketable haddock. The following four units of abundance were used:

Designation	Number of fish per half hour tow
Very heavy	300+
Heavy	150-300
Medium	50-150
Light	10-50

These charts showing the area fished by the commercial fleet and the location of the different age groups of haddock as determined by census tows during July and August of 1949 and 1950 are presented in figure 17. 6/

In July and August 1949, the maximum effort of the commercial fleet was expended in subarea J (see figure 11) with limited fishing taking place in subareas M and G. The distribution of the various age groups as determined from census tows showed that large concentrations of unmarketable haddock (1-2 years) were located in subareas J and M, but were also found in subareas N, O, and H which were outside the area fished by the commercial fleet. The maximum concentration of scrod haddock (3-4 years) was found in subareas M and J, but limited numbers were also caught by the Albatross III in deeper water in the western side of the channel (subarea G) and in the North East Rip (subareas H and J). 5-9+-year-old haddock were found in very limited concentrations in subareas J and M with the majority of these large haddock being located in the deep water of subareas G and H. The greatest concentration of all marketable haddock (3-9+ years) occurred in subareas J and M and extended considerably south of the location of maximum fleet effort. Relatively large concentrations of 3-9+ year haddock were also found in deep water in subareas G, H, and J.

It is seen then that in the summer of 1949 the commercial fleet concentrated on 1-4-year-old haddock and did not sample large areas, especially in deeper water, where the majority of older haddock and considerable quantities of scrod were found. This fact is substantiated by the age composition of the commercial catch during July and August, 1949.

6/ It must be kept in mind that a marked difference exists between the two sampling techniques involved. The commercial data is representative of the effort per unit area for a two month period while the census data is only representative of the age-group concentration during the short period required to sample a specific area. Because there is bound to be some movement of these concentrations over a two month period, the correlation between fishing effort and location is at best an approximation.

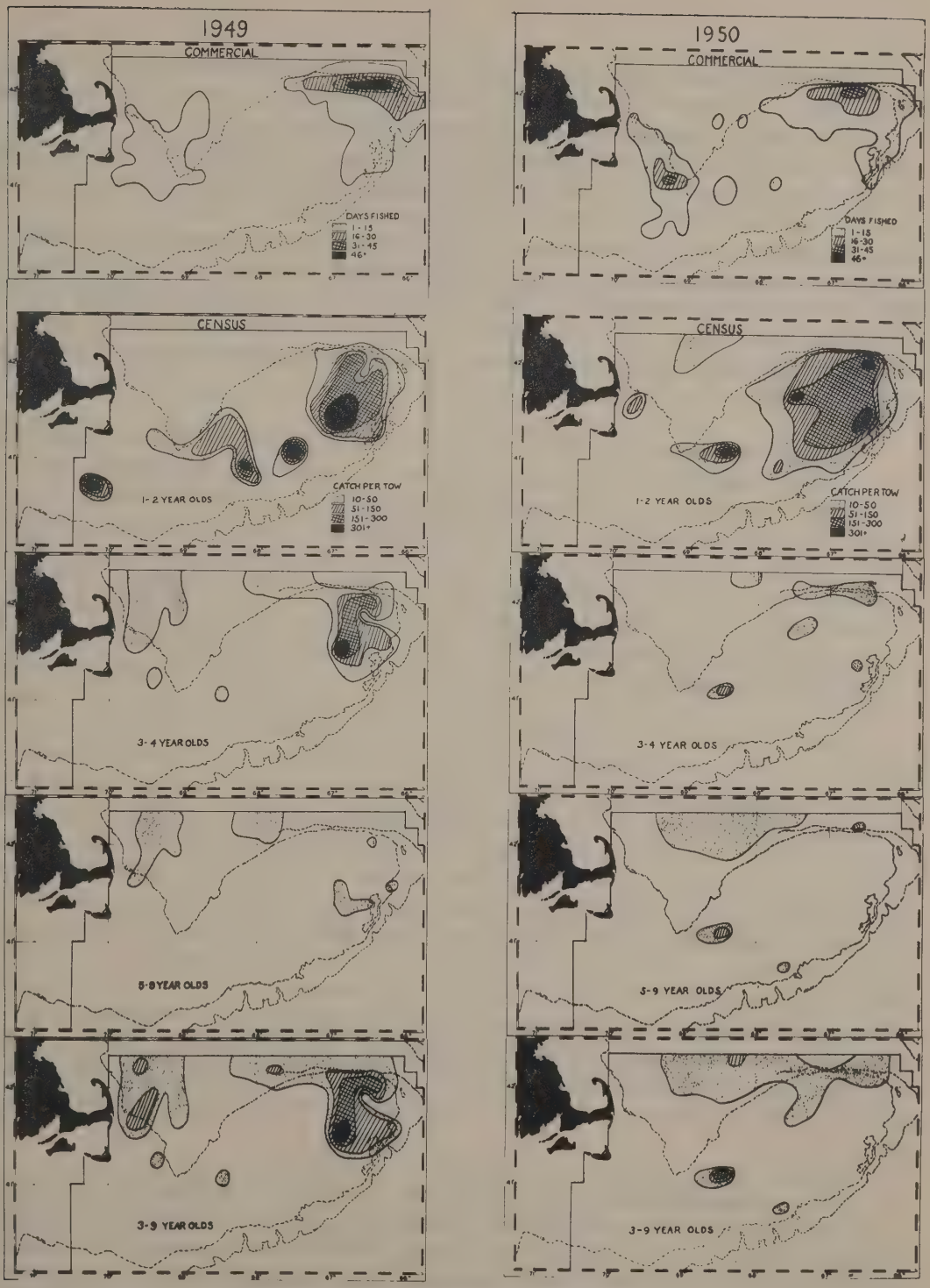

Figure 17.--Comparison of the distribution of haddock as determined from census tows and the location fished by the commercial fleet during July and August, 1949 and 1950.

In July and August 1950, the effort of the commercial fleet was more widely dispersed than in 1949 with the maximum effort expended in subarea J and the southern part of subarea G. Limited fishing also occurred in subareas M and O. The distribution of the various age groups as determined from census tows showed that the majority of unmarketable haddock occurred in subareas J and M with limited concentrations being located in the southern part of subarea G and in the northern limits of subarea N. No heavy concentrations of scrod were found anywhere on the bank that year and what limited concentrations did exist were within locations fished by the commercial fleet. The majority of large haddock were found in deeper water in subareas G, H, and J. The greater proportion of all marketable haddock were found in the deep water of subareas G, H, and J with limited numbers also occurring in the shoaler waters of subareas J, M, and N.

During the summer of 1950 the location of maximum effort of the commercial fleet coincided with the location of 1 and 2-year-old haddock as determined from census tows. The majority of these unmarketable haddock were 2-year-old fish of the strong 1948 year class. The concentrated effort on these fish by the commercial fleet is evidenced by the landings for July and August 1950, which consisted of more than 75 percent 2-year-old fish. A limited and completely isolated concentration of haddock of all ages found by the Albatross III at approximately 41°-05' North and 68°-30' West was also discovered by the fishing fleet. Again as in 1949 the older haddock were found principally in deeper water outside the area sampled by the commercial boats.

The concentration of the fleet in areas where smaller fish are abundant is reflected in the records of discarded haddock collected regularly in port by interview. These records show that the location of the greatest destruction of unmarketable fish during July and August of 1949 and 1950 was similar to the location of maximum fishing effort (subarea J). However, when this data is plotted in terms of the effort involved (pounds per-days-fishing) the distribution of these unmarketable haddock is seen to be quite similar to the distribution determined from the census data, being more widely dispersed in 1950 than in 1949 and in general with the greatest concentration of these unmarketable fish lying somewhat south of the areas of maximum effort. It is impossible to draw more than a general comparison between the 2 sets of data because of the inadequate coverage by the commercial fleet and the fluctuations of the age groups making up the bulk of these discarded fish. It is noteworthy, however, that this destruction drops markedly during the spring months as older fish are more available and also more completely segregated from the immature fish during this season.

It may be concluded then that during the summer of 1949 and 1950 the commercial fleet concentrated their efforts in depths shoaler than 60 fathoms and consequently on younger fish (2 to 4-year-olds). As stated previously it appears likely that during these months fishing in deeper water (greater than 90 fathoms) where the majority of older haddock were located and where younger fish occurred only in limited numbers would have proven more profitable and more desirable from a conservation standpoint.

SUMMARY AND CONCLUSIONS

1. The purpose of this study was to analyze the total and age distribution of haddock on Georges Bank by statistical subarea, depth and bottom type, and the variation of this distribution between seasons and years.

2. The total catch per tow of haddock for the bank as a whole varied markedly during the 3 years and these fluctuations resulted mainly from the fluctuation in numbers of younger fish.

3. Although the sampling of zero-ring fish was not adequate due to the size of the gear used, it did serve as an indication of year-class strength as evidenced from subsequent samplings and the catch of the commercial fleet.

4. Although relatively large quantities of zero-ring haddock were found in subareas N and O which long have been considered the principal nursery grounds for the Georges Bank stock of haddock, relatively high concentrations of these recently spawned fish were found outside of this area (subareas E, F, Q, and area XXIII). This occurrence of large numbers of zero-ring haddock in the Gulf of Maine and off southern New England and Long Island coincide with the occurrence of the strong 1948 and 1950 year classes and indicates that the recruitment of the Georges Bank stock is dependent upon fish spawned in or inhabiting, during their first year of life, areas outside the limits of Georges Bank, as well as those fish spending their complete life cycle on the bank proper.

5. The distribution by subarea was similar to that indicated by the commercial catch. During the summer the major portion of the haddock were found in subareas J and M and during the spring in subarea N.

6. In all three years, not only the percentage, but also actual numbers of older haddock (5 years and older) was greater in subareas G and H than over the rest of the bank.

7. During the summer months the catch and weight per tow of marketable haddock was greatest and that of unmarketable haddock least in depths greater than 90 fathoms, and thus it appears that it would have been both more profitable and expedient to have fished at these depths.

8. During the summer months few haddock of any age were found in the zone bounded by the 60 and 90 fathom lines. The scarcity of fish during this season in this depth zone could be due to the lack of suitable food.

9. The depth distribution during the spring indicated a migration of older fish into shoaler water at this time. During this season the greatest concentration of marketable haddock occurred in water shoaler than 60 fathoms.

10. The depth distribution of Georges Bank haddock during both spring and summer was similar to that of haddock in other regions and is apparently due to spawning and feeding migrations. This depth distribution was similar over various bottom types and although greater numbers of haddock occurred over sand than over mud bottoms, this distribution was incidental to the depth distribution.

11. The age composition of the commercial catch and of the census data when weighted in terms of effort by subarea of the commercial fleet were very similar, which fact further substantiates the reliability of the sampling methods.

12. Concentration charts showing the fishing location of the commercial fleet during July and August and the distribution of the various age haddock as determined from census cruises during similar periods reveal that the commercial fleet concentrated their efforts on younger haddock (2 to 4-year olds) and principally in subareas J and M and in depths between 30 and 60 fathoms and did not sample large areas of deeper water (more than 90 fathoms) in subareas G, H, and J where the majority of the older haddock occurred. This fact is further substantiated by the age composition of the commercial landings which reveal that it is only during the spawning season (spring) at which time these older haddock have moved into shoaler water that appreciable numbers of older haddock are caught.

13. Numerical mortalities based on census data were consistent with expected results in that they decreased uniformly for all age fish with shorter time limits between successive samplings. A marked contrast exists between these mortalities which show a decrease in the mortality of older fish and similar figures determined from the abundance data of the commercial catch over a considerable number of years which show a definite increase in the mortality of older fish. This is explained by the fact that these fish are being under sampled by the commercial fleet because of their location (deeper water) and not by the fact that there is an increased effort expended by the commercial fleet on these older fish with the resulting increase in fishing mortality.

14. The consistency of the age distribution by years, season, subareas, and depth; the uniformity of the mortalities determined from the spring and summer data; the accuracy of the year-class strength prediction based on the catch of zero-ring fish which was known to be the least reliable sample; and the similarity of the age distribution determined from census and commercial data all attest to the reliability and value of the data obtained and the methods used. It is believed that such methods with certain adaptations for specific needs and accuracy desired would prove most valuable in the study of migrations, year class strength, mortality and growth rates, and their relation to ecological conditions.

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Table A-1.--Numbers per tow and percentage age composition by subarea, area XXII

Number of tows	Subarea	Numbers per tow; age composition (in percent)	Age group										
			0	1	2	3	4	5	6	7	8	9 +	Total
						Summer 1948							
23	G	Numbers per tow	4.28	1.88	3.89	13.66	2.48	2.71	0.88	0.68	0.36	0.25	31.07
		Percent	13.78	6.05	12.52	43.97	7.98	8.72	2.83	2.19	1.16	0.80	100.00
20	H	Numbers per tow	0.71	3.26	14.56	7.67	2.05	1.38	0.79	0.80	0.50	0.49	32.21
		Percent	2.20	10.12	45.20	23.81	6.37	4.28	2.45	2.48	1.55	1.52	100.00
22	J	Numbers per tow	0.18	24.17	59.18	22.39	3.22	1.02	0.30	0.18	0.04	0.02	110.70
		Percent	0.16	21.83	53.45	20.22	2.90	0.92	0.27	0.16	0.03	0.01	100.00
24	M	Numbers per tow	0.88	1.29	2.10	0.70	0.19	0.10	0.14	0.14	0.05	0.03	5.62
		Percent	15.66	22.95	37.37	12.46	3.38	1.78	2.49	2.49	0.89	0.53	100.00
26	N	Numbers per tow	23.97	8.67	8.17	0.55	0.09	0.20	0.07	0.03	0.01	0	41.74
		Percent	57.43	20.77	19.57	1.32	0.22	0.48	0.17	0.07	0.02	0	100.00
27	O	Numbers per tow	8.30	0.05	0.37	0.10	0.17	0.06	0.01	0.01	0	0	9.07
		Percent	91.51	0.55	4.08	1.10	1.87	0.66	0.11	0.11	0	0	100.00
142	Total	Numbers per tow	6.93	6.32	13.76	7.00	1.27	0.86	0.34	0.28	0.15	0.12	37.03
		Percent	18.71	17.07	37.16	18.90	3.43	2.32	0.92	0.76	0.41	0.32	100.00
						Summer 1949							
20	G	Numbers per tow	0.05	2.19	1.65	4.48	10.29	4.86	1.97	1.06	0.62	0.69	27.86
		Percent	0.18	7.86	5.92	16.08	36.93	17.44	7.07	3.81	2.23	2.48	100.00
19	H	Numbers per tow	0.05	19.64	1.35	1.89	3.23	1.43	0.87	0.48	0.41	0.52	29.87
		Percent	0.17	65.75	4.52	6.33	10.81	4.79	2.91	1.61	1.37	1.74	100.00
11	J	Numbers per tow	0	64.48	51.80	71.60	24.33	3.15	0.61	0.30	0.14	0.15	216.56
		Percent	0	29.77	23.92	33.07	11.23	1.45	0.28	0.13	0.07	0.07	100.00
24	M	Numbers per tow	0.38	341.28	23.48	25.32	9.88	3.93	1.09	0.53	0.21	0.06	406.16
		Percent	0.09	84.03	5.78	6.23	2.43	0.97	0.25	0.13	0.05	0.01	100.00
24	N	Numbers per tow	0.90	72.04	0.39	0	0	0	0	0	0	0	73.33
		Percent	1.23	98.24	0.53	0	0	0	0	0	0	0	100.00
24	O	Numbers per tow	0	49.81	2.60	0	0	0	0	0	0	0	52.41
		Percent	0	95.04	4.96	0	0	0	0	0	0	0	100.00
122	Total	Numbers per tow	0.27	100.34	10.63	12.53	6.74	2.08	0.73	0.38	0.22	0.22	133.87
		Percent	0.20	74.95	7.74	9.36	5.03	1.55	0.55	0.28	0.16	0.16	100.00
						Summer 1950							
17	G	Numbers per tow	16.12	5.57	3.71	1.17	1.21	2.41	1.21	0.83	0.34	0.30	32.87
		Percent	49.04	16.95	11.29	3.56	3.68	7.33	3.68	2.53	1.03	0.91	100.00
20	H	Numbers per tow	0.20	5.79	27.77	4.05	3.58	6.95	2.64	1.17	0.34	0.27	52.76
		Percent	0.38	10.97	52.64	7.68	6.79	13.17	5.00	2.22	0.64	0.51	100.00
14	J	Numbers per tow	9.30	28.41	75.94	4.76	5.27	4.18	1.15	0.42	0.12	0.11	129.66
		Percent	7.17	21.91	58.57	3.67	4.06	3.22	0.89	0.32	0.09	0.08	100.00
22	M	Numbers per tow	0.12	25.08	79.39	1.83	0.97	0.63	0.16	0.13	0.09	0.07	108.47
		Percent	0.11	23.12	73.19	1.69	0.89	0.58	0.15	0.12	0.08	0.07	100.00
22	N	Numbers per tow	33.55	2.82	10.87	0.23	0.36	0.41	0.38	0.24	0.10	0.06	49.00
		Percent	68.47	5.76	22.18	0.47	0.74	0.84	0.78	0.49	0.20	0.12	100.00
26	O	Numbers per tow	23.16	0	0	0	0	0	0	0	0	0	23.16
		Percent	100.00	0	0	0	0	0	0	0	0	0	100.00
121	Total	Numbers per tow	14.47	10.10	30.31	1.76	1.61	2.16	0.84	0.43	0.15	0.12	61.95
		Percent	23.36	16.30	48.12	2.84	2.60	3.49	1.36	0.69	0.24	0.19	100.00
						Summer Average 1949-1950							
37	G	Numbers per tow	7.43	3.74	2.60	2.95	6.12	3.73	1.64	0.95	0.49	0.51	30.16
		Percent	24.64	12.40	8.62	9.78	20.29	12.37	5.44	3.15	1.63	1.69	100.00
39	H	Numbers per tow	0.15	12.54	14.90	3.00	3.40	4.26	1.78	0.82	0.37	0.39	41.61
		Percent	0.36	30.14	35.81	7.21	8.17	10.24	4.28	1.97	0.89	0.94	100.00
25	J	Numbers per tow	5.21	44.28	65.31	34.17	13.66	3.73	0.91	0.37	0.13	0.13	167.90
		Percent	3.10	26.37	38.90	20.35	8.14	2.22	0.54	0.22	0.08	0.08	100.00
46	M	Numbers per tow	0.26	190.05	50.22	14.09	5.62	2.35	0.64	0.34	0.15	0.07	263.79
		Percent	0.10	72.05	19.04	5.34	2.13	0.89	0.24	0.13	0.06	0.03	100.00
46	N	Numbers per tow	16.52	38.93	5.40	0.11	0.17	0.19	0.18	0.11	0.05	0.03	61.69
		Percent	26.78	63.11	8.75	0.18	0.28	0.31	0.29	0.18	0.08	0.05	100.00
50	O	Numbers per tow	12.04	23.91	1.25	0	0	0	0	0	0	0	37.20
		Percent	32.37	64.27	3.36	0	0	0	0	0	0	0	100.00
243	Total	Numbers per tow	7.34	55.40	20.92	7.13	3.98	2.12	0.78	0.40	0.19	0.17	97.80
		Percent	7.51	56.65	20.75	7.29	4.07	2.17	0.80	0.41	0.19	0.17	100.00
						Spring 1950 (subareas H, J, M, and N)							
19	H	Numbers per tow		1.46	19.55	3.51	4.63	6.38	2.77	1.83	0.65	0.86	41.64
		Percent		3.50	46.95	8.43	11.12	15.32	6.65	4.39	1.56	2.07	100.00
13	J	Numbers per tow		28.88	25.74	3.80	5.26	3.15	0.64	0.26	0.06	0.12	67.90
		Percent		42.53	37.91	5.60	7.75	4.64	0.94	0.38	0.09	0.05	100.00
21	M	Numbers per tow		21.42	58.03	13.85	7.17	4.18	1.19	0.27	0.05	0.02	106.18
		Percent		20.17	54.65	13.04	6.75	3.94	1.12	0.25	0.05	0.02	100.00
25	N	Numbers per tow		6.80	125.33	2.22	1.78	1.38	0.40	0.22	0.06	0.09	138.28
		Percent		4.92	90.63	1.61	1.29	1.00	0.29	0.16	0.04	0.07	100.00
78	Total	Numbers per tow		13.11	64.84	5.93	4.51	3.64	1.22	0.63	0.20	0.26	94.34
		Percent		13.90	68.73	6.29	4.78	3.86	1.28	0.67	0.21	0.28	100.00

Table A-2.--Number per tow and percentage age composition by depth zone, area XXII

Number of tows	Depth zone	Numbers per tow; age composition (in percent)	Age group 0	1	2	3	4	5	6	7	8	9 +	Total
						Summer 1948							
27	1	Numbers per tow	3.30	0.78	1.74	5.49	1.84	0.92	0.26	0.20	0.08	0.09	14.72
		Percent	22.42	5.30	11.82	37.30	12.50	6.25	1.90	1.36	0.54	0.61	100.00
65	2	Numbers per tow	12.36	13.28	28.78	8.44	1.13	0.40	0.14	0.10	0.03	0.02	64.68
		Percent	19.11	20.53	44.49	13.05	1.75	0.62	0.22	0.15	0.05	0.03	100.00
19	3	Numbers per tow	4.25	0.16	0.22	0.61	0.37	0.19	0.11	0.10	0.06	0.01	6.08
		Percent	69.90	2.63	3.62	10.03	6.09	3.13	1.81	1.64	0.99	0.16	100.00
31	4	Numbers per tow	0.37	0.34	1.09	9.22	1.61	2.16	0.94	0.83	0.50	0.42	17.48
		Percent	2.12	1.94	6.23	52.75	9.21	12.36	5.38	4.75	2.86	2.40	100.00
						Summer 1949							
27	1	Numbers per tow	0.05	106.58	3.38	2.15	3.58	1.24	0.34	0.14	0.05	0.10	117.61
		Percent	0.04	90.62	2.87	1.83	3.04	1.06	0.29	0.12	0.04	0.09	100.00
53	2	Numbers per tow	0.60	176.54	21.45	25.45	8.87	2.27	0.58	0.28	0.11	0.03	236.18
		Percent	0.25	74.75	9.08	10.78	3.75	0.96	0.25	0.12	0.05	0.01	100.00
15	3	Numbers per tow	0	0.06	0.32	0.26	0.45	0.19	0.10	0.06	0.02	0.01	1.47
		Percent	0	4.08	21.77	17.69	30.61	12.93	6.80	4.08	1.36	0.68	100.00
27	4	Numbers per tow	0	0.22	1.14	4.08	7.34	3.60	1.75	0.99	0.72	0.82	20.66
		Percent	0	1.06	5.52	19.75	35.53	17.43	8.47	4.79	3.48	3.97	100.00
						Summer 1950							
32	1	Numbers per tow	0.07	9.10	32.99	2.80	2.03	3.49	1.15	0.35	0.07	0.04	52.09
		Percent	0.13	17.47	63.33	5.38	3.90	6.70	2.21	0.67	0.13	0.08	100.00
54	2	Numbers per tow	27.62	16.95	47.35	1.58	1.12	0.83	0.30	0.18	0.08	0.06	96.07
		Percent	28.75	17.64	49.29	1.65	1.17	0.86	0.31	0.19	0.08	0.06	100.00
16	3	Numbers per tow	2.49	0.53	0.52	0.15	0.19	0.49	0.36	0.26	0.13	0.11	5.23
		Percent	47.61	10.13	9.94	2.88	3.63	9.37	6.88	4.97	2.49	2.10	100.00
19	4	Numbers per tow	11.44	0.38	2.43	1.86	3.51	5.11	2.22	1.40	0.51	0.46	29.32
		Percent	39.02	1.30	8.29	6.34	11.97	17.43	7.57	4.77	1.74	1.57	100.00
						Summer average 1949-1950							
59	1	Numbers per tow	0.06	53.71	19.44	2.50	2.74	2.46	0.78	0.25	0.06	0.07	82.07
		Percent	0.07	65.44	23.69	3.05	3.34	3.00	0.95	0.30	0.07	0.09	100.00
107	2	Numbers per tow	14.23	96.00	34.51	13.41	4.96	1.54	0.44	0.23	0.10	0.05	165.47
		Percent	8.60	58.02	20.86	8.10	3.00	0.93	0.27	0.14	0.06	0.03	100.00
31	3	Numbers per tow	1.29	0.31	0.42	0.20	0.32	0.34	0.22	0.17	0.08	0.06	3.41
		Percent	37.83	9.09	12.32	5.87	9.38	9.97	6.45	4.99	2.35	1.76	100.00
46	4	Numbers per tow	4.73	0.29	1.57	3.16	5.77	4.22	1.94	1.16	0.63	0.67	24.24
		Percent	19.51	1.20	6.89	13.04	23.80	17.41	8.00	4.79	2.60	2.76	100.00
						Spring 1950 (subareas H, J, M, and N)							
21	1	Numbers per tow		2.35	174.47	16.83	9.25	7.79	2.84	1.33	0.44	0.46	215.76
		Percent		0.92	80.86	7.80	4.29	3.61	1.32	0.62	0.02	0.02	100.00
33	2	Numbers per tow		20.90	40.56	3.00	4.03	2.36	0.48	0.22	0.05	0.09	71.69
		Percent		29.15	56.58	4.18	5.62	3.29	0.67	0.31	0.07	0.13	100.00
11	3	Numbers per tow		14.31	1.76	0.74	1.87	3.39	1.62	1.21	0.38	0.50	25.78
		Percent		55.51	6.83	2.87	7.25	13.15	6.28	4.69	1.47	1.94	100.00
13	4	Numbers per tow		9.73	2.78	0.15	0.27	0.45	0.19	0.08	0.04	0.18	13.85
		Percent		70.25	20.07	1.08	1.95	3.25	1.37	0.58	0.28	1.30	100.00

Table A-3.--Numbers per tow and percentage age composition by bottom type, (sand, stony, mud, mud and sand), area XXII

Number of tows	Bottom type	Numbers per tow; age composition (in percent)	Age group 0	1	2	3	4	5	6	7	8	9 +	Total
							Summer 1948						
86	Sand	Numbers per tow	10.99	9.78	19.12	6.47	1.32	0.60	0.22	0.17	0.07	0.04	48.78
		Percent	22.53	20.04	39.20	13.26	2.71	1.23	0.45	0.35	0.14	0.08	100.00
14	Stony	Numbers per tow	0	3.39	20.26	11.52	1.45	0.36	0.15	0.08	0.02	0.01	37.24
		Percent	0	9.10	54.40	30.92	3.89	0.96	0.44	0.22	0.05	0.03	100.00
23	Mud	Numbers per tow	0.51	0.26	0.62	8.59	0.38	1.56	0.52	0.39	0.26	0.19	13.28
		Percent	3.84	1.96	4.67	64.68	2.85	11.73	3.91	2.93	2.00	1.42	100.00
19	Mud-Sand	Numbers per tow	1.47	0.16	0.71	4.17	2.00	1.51	0.79	0.78	0.46	0.46	12.51
		Percent	11.75	1.28	5.67	33.33	15.99	12.07	6.31	6.24	3.68	3.68	100.00
							Summer 1949						
66	Sand	Numbers per tow	0.44	152.85	9.92	10.39	4.95	1.84	0.45	0.22	0.09	0.06	181.21
		Percent	0.24	84.35	5.47	5.73	2.73	1.02	0.25	0.12	0.05	0.03	100.00
23	Stony	Numbers per tow	0.17	41.96	23.04	34.57	14.10	2.68	1.12	0.58	0.40	0.41	119.03
		Percent	0.14	35.25	19.36	29.03	11.84	2.25	0.94	0.48	0.34	0.37	100.00
19	Mud	Numbers per tow	0	0.18	0.85	1.98	6.01	3.35	1.57	0.88	0.57	0.67	16.06
		Percent	0	1.12	5.29	12.33	37.42	20.86	9.78	5.48	3.55	4.17	100.00
14	Mud-Sand	Numbers per tow	0	84.64	4.45	0.18	0.51	0.50	0.22	0.11	0.07	0.03	90.71
		Percent	0	93.31	4.91	0.20	0.56	0.55	0.24	0.12	0.08	0.03	100.00
							Summer 1950						
67	Sand	Numbers per tow	21.35	10.68	31.86	1.75	1.47	2.31	0.89	0.42	0.15	0.10	70.98
		Percent	30.08	15.05	44.89	2.47	2.07	3.25	1.25	0.59	0.21	0.14	100.00
18	Stony	Numbers per tow	2.90	22.58	74.21	4.04	3.54	2.33	0.46	0.16	0.04	0.07	110.33
		Percent	2.63	20.47	67.26	3.66	3.20	2.11	0.42	0.15	0.04	0.06	100.00
15	Mud	Numbers per tow	15.48	3.54	5.00	1.00	1.35	2.77	1.43	0.98	0.37	0.35	32.27
		Percent	47.97	10.97	15.49	3.10	4.18	8.58	4.43	3.04	1.15	1.09	100.00
21	Mud-Sand	Numbers per tow	1.72	2.25	5.80	0.36	0.62	1.11	0.56	0.27	0.11	0.08	12.88
		Percent	13.35	17.47	45.03	2.80	4.81	8.62	4.35	2.10	0.85	0.62	100.00
							Summer average 1949-1950						
133	Sand	Numbers per tow	10.79	81.23	20.98	6.04	3.19	2.07	0.68	0.32	0.12	0.08	125.68
		Percent	8.65	64.63	16.69	4.81	2.54	1.65	0.54	0.25	0.10	0.06	100.00
41	Stony	Numbers per tow	1.37	33.45	45.51	21.17	9.47	2.52	0.83	0.39	0.24	0.26	115.21
		Percent	1.19	29.02	39.50	18.38	8.22	2.19	0.72	0.34	0.21	0.23	100.00
34	Mud	Numbers per tow	6.83	1.66	2.68	1.55	3.95	3.09	1.51	0.93	0.48	0.53	23.21
		Percent	29.43	7.15	11.55	6.68	17.02	13.30	6.41	4.01	2.07	2.28	100.00
35	Mud-Sand	Numbers per tow	1.03	35.20	5.26	0.29	0.58	0.87	0.42	0.21	0.09	0.06	44.01
		Percent	2.34	79.98	11.95	0.66	1.32	1.98	0.95	0.48	0.20	0.14	100.00
							Spring 1950 (subareas H, J, M, and N)						
48	Sand	Numbers per tow		9.80	96.26	4.44	5.09	4.37	1.50	0.86	0.27	0.33	122.93
		Percent		7.97	78.31	3.61	4.14	3.56	1.22	0.70	0.22	0.27	100.00
20	Stony	Numbers per tow		20.71	21.86	12.45	5.33	3.69	1.16	0.40	0.11	0.20	65.92
		Percent		31.41	33.16	18.89	8.09	5.61	1.76	0.61	0.17	0.30	100.00
2	Mud	Numbers per tow		0	0	0	0.09	0.51	0.31	0.13	0.16	0.31	1.50
		Percent		0	0	0	5.32	34.00	20.69	8.67	10.67	20.67	100.00
8	Mud-Sand	Numbers per tow		0	17.31	0	0	0	0	0	0	0	17.31
		Percent		0	100.00	0	0	0	0	0	0	0	100.00
							(Bottom types grouped-sand=sand and stony, mud=mud and mud-sand) area XXII Summer 1948						
100	Sand	Numbers per tow	9.45	8.89	19.27	7.17	1.34	0.58	0.21	0.16	0.06	0.04	47.16
		Percent	20.04	18.85	40.86	15.20	2.84	1.21	0.45	0.34	0.13	0.08	100.00
42	Mud	Numbers per tow	0.95	0.21	0.67	6.59	1.11	1.54	0.64	0.57	0.35	0.31	12.94
		Percent	7.34	1.62	5.18	50.93	8.58	11.90	4.95	4.40	2.70	2.40	100.00
							Summer 1949						
89	Sand	Numbers per tow	0.37	124.19	13.32	16.64	7.31	2.06	0.63	0.32	0.17	0.15	165.14
		Percent	0.22	75.20	8.07	10.08	4.42	1.25	0.38	0.19	0.10	0.09	100.00
33	Mud	Numbers per tow	0	36.01	2.38	1.22	3.67	2.14	1.00	0.56	0.36	0.40	47.73
		Percent	0	75.44	4.99	2.56	7.69	4.47	2.09	1.17	0.75	0.84	100.00
							Summer 1950						
85	Sand	Numbers per tow	17.43	13.20	40.82	2.24	1.91	2.31	0.80	0.37	0.13	0.10	79.32
		Percent	22.00	16.64	51.46	2.82	2.41	2.90	1.01	0.47	0.16	0.13	100.00
36	Mud	Numbers per tow	7.45	2.79	5.47	0.63	0.93	1.80	0.92	0.57	0.21	0.19	20.96
		Percent	35.54	13.31	26.10	3.00	4.44	8.59	4.39	2.72	1.00	0.91	100.00
							Summer, Average 1949-1950						
174	Sand	Numbers per tow	8.71	69.97	26.76	9.60	4.67	2.18	0.71	0.34	0.15	0.12	123.21
		Percent	7.07	56.79	21.72	7.79	3.79	1.77	0.58	0.27	0.12	0.10	100.00
69	Mud	Numbers per tow	3.89	18.68	3.99	0.91	2.24	1.96	0.96	0.56	0.28	0.29	33.76
		Percent	11.52	55.33	11.82	2.70	6.63	5.81	2.84	1.66	0.83	0.86	100.00
							Spring 1950 (Subareas H, J, M, and N)						
68	Sand	Numbers per tow		13.01	74.38	6.80	5.17	4.17	1.40	0.72	0.23	0.29	106.14
		Percent		12.26	70.06	6.40	4.86	3.93	1.32	0.68	0.22	0.27	100.00
10	Mud	Numbers per tow		13.85	0	0	0.02	0.10	0.06	0.03	0.03	0.06	14.15
		Percent		97.98	0	0	0.13	0.68	0.41	0.20	0.20	0.40	100.00

Table A-4.--Numbers per tow of each age by bottom type and depth zone. Subarea G.

Depth zone	Bottom type	Number of tows	Age group 0	1	2	3	4	5	6	7	8	9 +	Total
							Summer 1948						
	Sand	2	4.00	9.29	10.27	45.98	20.93	11.71	3.48	2.56	1.03	1.21	110.46
	Stony	0											
I	Mud	0											
	Mud and sand	1	0	0	0	0	0	0	0	0	0	0	0
	Total	3	2.67	6.19	6.85	30.65	13.95	7.81	2.32	1.71	0.69	0.81	73.65
	Sand	4	6.50	4.00	12.70	4.25	0.80	0.15	0	0	0	0	28.40
	Stony	0											
II	Mud	0											
	Mud and sand	0											
	Total	4	6.50	4.00	12.70	4.25	0.80	0.15	0	0	0	0	28.40
	Sand	3	19.30	0.93	1.19	3.60	1.82	1.06	0.64	0.65	0.36	0.04	29.59
	Stony	0											
III	Mud	0											
	Mud and sand	0											
	Total	3	19.30	0.93	1.19	3.60	1.82	1.06	0.64	0.65	0.36	0.04	29.59
	Sand	0											
	Stony	0											
IV	Mud	13	0.50	0.45	1.12	14.96	0.50	2.70	0.88	0.65	0.40	0.25	22.41
	Mud and sand	0											
	Total	13	0.50	0.45	1.12	14.96	0.50	2.70	0.88	0.65	0.40	0.25	22.41
	Sand	9	10.21	4.15	8.32	13.31	5.61	3.02	0.99	0.79	0.35	0.28	47.03
	Stony	0											
Total	Mud	13	0.50	0.45	1.12	14.96	0.50	2.70	0.88	0.65	0.40	0.25	22.41
	Mud and sand	1	0	0	0	0	0	0	0	0	0	0	0
							Summer 1949						
	Sand	4	0	5.91	3.39	11.65	20.62	7.63	2.02	0.75	0.26	0.17	52.40
	Stony	0											
I	Mud	0											
	Mud and sand	0											
	Total	4	0	5.91	3.39	11.65	20.62	7.63	2.02	0.75	0.26	0.17	52.40
	Sand	2	0.50	8.34	0.69	0.33	0.56	0.07	0.18	0.23	0.06	0.04	11.00
	Stony	0											
II	Mud	0											
	Mud and sand	0											
	Total	2	0.50	8.34	0.69	0.33	0.56	0.07	0.18	0.23	0.06	0.04	11.00
	Sand	0											
	Stony	0											
III	Mud	1	0	0.01	0.80	1.04	2.79	0.88	0.65	0.63	0.17	0.03	7.00
	Mud and sand	0											
	Total	1	0	0.01	0.80	1.04	2.79	0.88	0.65	0.63	0.17	0.03	7.00
	Sand	2	0	0	0.93	2.36	4.08	1.50	0.62	0.45	0.25	0.08	10.27
	Stony	0											
IV	Mud	11	0	0.31	1.40	3.33	10.12	5.70	2.65	1.47	0.96	1.16	27.10
	Mud and sand	0											
	Total	13	0	0.26	1.33	3.18	9.19	5.06	2.34	1.31	0.85	0.99	24.51
	Sand	8	0.13	5.04	2.10	6.50	11.74	4.21	1.21	0.55	0.21	0.12	31.54
	Stony	0											
Total	Mud	12	0	0.29	1.35	3.14	9.51	5.30	2.48	1.40	0.89	1.07	25.43
	Mud and sand	0											
							Summer 1950						
	Sand	3	0	23.74	11.60	3.32	1.55	1.73	0.62	0.13	0.01	0	42.70
	Stony	0											
I	Mud	0											
	Mud and sand	0											
	Total	3	0	23.74	11.60	3.32	1.55	1.73	0.62	0.13	0.01	0	42.70
	Sand	1	25.00	14.10	1.46	0.75	0.60	0.09	0	0	0	0	42.00
	Stony	0											
II	Mud	0											
	Mud and sand	1	1.00	1.91	0.09	0	0	0	0	0	0	0	3.00
	Total	2	13.00	8.00	0.78	0.37	0.30	0.05	0	0	0	0	22.50
	Sand	3	8.30	0.88	0.30	0.23	0.49	0.83	0.43	0.24	0.15	0.05	11.90
	Stony	0											
III	Mud	1	8.00	0	1.17	0.64	0.18	0.01	0	0	0	0	10.00
	Mud and sand	0											
	Total	4	8.23	0.66	0.52	0.33	0.41	0.63	0.32	0.18	0.11	0.04	11.43
	Sand	0											
	Stony	0											
IV	Mud	8	26.90	0.60	3.08	0.99	1.71	4.14	2.18	1.63	0.65	0.62	42.50
	Mud and sand	0											
	Total	8	26.90	0.60	3.08	0.99	1.71	4.14	2.18	1.63	0.65	0.62	42.50
	Sand	7	7.13	12.56	5.31	1.63	0.96	1.11	0.45	0.16	0.07	0.02	29.40
	Stony	0											
Total	Mud	9	24.80	0.53	2.87	0.95	1.54	3.68	1.94	1.45	0.58	0.55	38.89
	Mud and sand	1	1.00	1.91	0.09	0	0	0	0	0	0	0	3.00

Table A-5.—Numbers per tow of each age by bottom type and depth zone. Subarea H

Depth zone	Bottom type	Number of tows for each age group	Age group 0	1	2	3	4	5	6	7	8	9 +	Total
						Spring 1948							
	Sand	2	0	0	0.04	0.87	0.08	0.01	0	0	0	0	1.00
	Stony	0											
I	Mud	0											
	Mud and sand	0											
	Total	2	0	0	0.04	0.87	0.08	0.01	0	0	0	0	1.00
	Sand	7	1.60	8.77	39.53	11.65	1.16	0.18	0.01	0	0	0	62.90
	Stony	0											
II	Mud	0											
	Mud and sand	0											
	Total	7	1.60	8.77	39.53	11.65	1.16	0.18	0.01	0	0	0	62.90
	Sand	0											
	Stony	0											
III	Mud	1	0	0	0	0.37	1.14	0.40	0.06	0.03	0	0	2.00
	Mud and sand	0											
	Total	1	0	0	0	0.37	1.14	0.40	0.06	0.03	0	0	2.00
	Sand	4	0	0.29	0.50	0.61	0.46	0.26	0.22	0.24	0.11	0.01	2.70
	Stony	0											
IV	Mud	1	0	0	0.02	2.77	1.05	0.36	0.49	0.53	0.76	1.02	7.00
	Mud and sand	5	0.60	0.54	2.46	12.90	5.72	4.92	2.86	2.90	1.76	1.73	36.39
	Total	10	0.30	0.39	1.43	6.97	3.15	2.60	1.57	1.60	1.00	0.97	19.98
	Sand	13	0.86	4.81	21.45	6.60	0.78	0.18	0.07	0.07	0.03	0	34.85
	Stony	0											
Total	Mud	2	0	0	0.01	1.57	1.10	0.38	0.28	0.28	0.38	0.51	4.51
	Mud and sand	5	0.60	0.54	2.46	12.90	5.72	4.92	2.86	2.90	1.76	1.73	36.39
						Summer 1949							
	Sand	4	0	81.22	3.47	2.84	3.54	0.76	0.28	0.22	0.05	0.52	92.90
	Stony	1	0	0	0	0	0	0	0	0	0	0	0
I	Mud	0											
	Mud and sand	0											
	Total	5	0	64.98	2.78	2.27	2.83	0.61	0.22	0.18	0.04	0.42	74.32
	Sand	2	0.50	23.48	3.52	0.72	0.26	0.02	0	0	0	0	28.50
	Stony	0											
II	Mud	0											
	Mud and sand	0											
	Total	2	0.50	23.48	3.52	0.72	0.26	0.02	0	0	0	0	28.50
	Sand	2	0	0	0	0.17	1.03	0.26	0.04	0	0	0	1.50
	Stony	0											
III	Mud	1	0	0	0	0	0	0	0	0	0	0	0
	Mud and sand	0											
	Total	3	0	0	0	0.11	0.69	0.17	0.03	0	0	0	1.00
	Sand	3	0	0	0	0.05	0.44	0.10	0.01	0	0	0	0.60
	Stony	4	0	0.34	1.11	5.04	9.06	4.07	3.05	1.66	1.63	1.84	27.80
IV	Mud	0											
	Mud and sand	2	0	0	0.13	1.23	3.57	3.53	1.54	0.78	0.50	0.22	11.50
	Total	9	0	0.15	0.52	2.53	4.97	2.63	1.70	0.91	0.83	0.87	15.11
	Sand	11	0.09	33.80	1.90	1.21	1.64	0.36	0.11	0.08	0.02	0.19	39.40
	Stony	5	0	0.27	0.89	4.03	7.25	3.09	2.44	1.33	1.30	1.47	22.07
Total	Mud	1	0	0	0	0	0	0	0	0	0	0	0
	Mud and sand	2	0	0	0.13	1.23	3.57	3.53	1.54	0.78	0.50	0.22	11.50
						Summer 1950							
	Sand	5	0	6.37	88.19	12.42	9.61	19.00	6.11	1.77	0.31	0.21	143.99
	Stony	1	0	0	0	0	0	0	0	0	0	0	0
I	Mud	1	0	48.24	48.24	6.44	6.48	8.44	3.99	1.61	0.29	0.27	124.00
	Mud and sand	1	0	0	0	0	0	0	0	0	0	0	0
	Total	8	0	10.01	61.15	8.57	6.82	12.92	4.32	1.31	0.23	0.16	105.49
	Sand	3	0	9.97	19.78	2.53	2.38	3.60	1.03	0.54	0.20	0.14	40.17
	Stony	0											
II	Mud	0											
	Mud and sand	0	0	0	0	0	0	0	0	0	0	0	0
	Total	6	0	4.99	9.89	1.26	1.19	1.80	0.52	0.27	0.10	0.07	20.09
	Sand	0											
	Stony	0											
III	Mud	1	4.00	0	0.95	0.05	0	0	0	0	0	0	5.00
	Mud and sand	2	0	2.95	1.92	0.19	0.35	2.13	1.84	1.31	0.66	0.65	12.00
	Total	3	1.33	1.97	1.60	0.14	0.24	1.42	1.23	0.87	0.44	0.43	9.67
	Sand	3	0	0	0.67	1.48	3.10	6.81	3.83	2.92	1.01	0.78	20.60
	Stony	0											
IV	Mud	0											
	Mud and sand	0											
	Total	3	0	0	0.67	1.48	3.10	6.81	3.83	2.92	1.01	0.78	20.60
	Sand	11	0	5.61	45.66	6.74	5.86	11.48	4.10	1.75	0.47	0.35	82.02
	Stony	1	0	0	0	0	0	0	0	0	0	0	0
Total	Mud	2	2.00	24.12	24.59	3.24	3.24	4.22	2.00	0.80	0.15	0.14	64.50
	Mud and sand	6	0	0.98	0.64	0.06	0.12	0.71	0.61	0.44	0.22	0.22	4.00
						Spring 1950							
	Sand	4		0.30	84.57	13.27	13.99	17.65	7.35	4.71	1.78	1.93	145.55
	Stony	1		17.00	13.75	7.68	9.84	8.60	3.31	2.02	0.46	1.34	64.00
I	Mud	0											
	Mud and sand	0											
	Total	5		3.64	70.41	12.15	13.16	15.84	6.54	4.17	1.52	1.81	129.24

Table A-5.—Numbers per tow of each age by bottom type and depth zone, Subarea H - Continued.

Depth zone	Bottom type	Number of tows for each age group	Age group									
			0	1	2	3	4	5	6	7	8	9 +	Total
			Spring 1950 (cont.)										
II	Sand	3		0.90	0.88	0.25	0.54	0.78	0.19	0.06	0.05	0.04	3.69
	Stony	0											
	Mud	0											
	Mud and sand	0											
	Total	3		0.90	0.88	0.25	0.54	0.78	0.19	0.06	0.05	0.04	3.69
III	Sand	2		0	7.42	2.27	9.75	18.63	8.93	6.66	2.11	2.74	58.51
	Stony	0											
	Mud	1		0	0	0	0	0	0	0	0	0	0
	Mud and sand	0											
	Total	3		0	4.95	1.51	6.50	12.42	5.95	4.44	1.41	1.83	39.01
IV	Sand	2		2.00	0.43	0.29	0.47	0.52	0.23	0.05	0	0.01	4.00
	Stony	2		1.00	0.50	0	0.01	0.22	0.21	0.05	0	0.51	2.50
	Mud	1		0	0	0	0.17	1.02	0.62	0.26	0.31	0.62	3.00
	Mud and sand	3		0.30	0	0	0	0	0	0	0	0	0.30
	Total	8		0.86	0.23	0.07	0.14	0.31	0.19	0.06	0.04	0.21	2.11
Total	Sand	11		0.72	32.42	5.36	7.09	10.11	4.39	2.95	1.04	1.21	65.30
	Stony	3		6.33	4.92	2.56	3.28	3.01	1.24	0.71	0.15	0.79	23.00
	Mud	2		0	0	0	0.09	0.51	0.31	0.13	0.16	0.31	1.50
	Mud and sand	3		0.30	0	0	0	0	0	0	0	0	0.30

Table A-6.--Numbers per tow of each age by bottom type and depth zone. Subarea J

Depth zone	Bottom type	Number of tows	Age group 0	1	2	3	4	5	6	7	8	9 +	Total
Summer 1948													
I	Sand	0											
	Stony	3	0	0.41	8.79	18.15	2.55	0.51	0.17	0.10	0.03	0.03	30.74
	Mud	0											
	Mud and sand	0											
	Total	3	0	0.41	8.79	18.15	2.55	0.51	0.17	0.10	0.03	0.03	30.74
II	Sand	7	0	70.35	146.19	44.26	5.53	1.65	0.33	0.23	0.06	0.04	268.64
	Stony	5	0	7.42	49.48	21.36	2.52	0.70	0.31	0.17	0.03	0	81.99
	Mud	0											
	Mud and sand	0											
	Total	12	0	44.13	105.89	34.72	4.28	1.25	0.32	0.21	0.05	0.02	190.87
III	Sand	1	2.00	0	0	0	0	0	0	0	0	0	2.00
	Stony	0											
	Mud	0											
	Mud and sand	0											
	Total	1	2.00	0	0	0	0	0	0	0	0	0	2.00
IV	Sand	5	0	0.11	0.74	1.39	0.51	0.32	0.27	0.18	0.05	0.02	3.59
	Stony	0											
	Mud	0											
	Mud and sand	1	2.00	0.39	1.32	14.71	9.39	4.14	0.76	0.30	0	0	33.00
	Total	6	0.33	0.16	0.82	3.59	1.99	0.96	0.35	0.20	0.04	0.02	8.46
Total	Sand	13	0.16	37.92	79.00	24.37	3.18	1.01	0.28	0.19	0.05	0.03	146.19
	Stony	8	0	4.79	34.22	20.16	2.53	0.63	0.26	0.14	0.03	0.01	62.77
	Mud	0											
	Mud and sand	1	2.00	0.39	1.32	14.71	6.39	4.14	0.76	0.30	0	0	33.00
Summer 1949													
I			No tows					No tows				No tows	
II	Sand	1	0	78.34	70.60	48.20	2.87	0	0	0	0	0	200.00
	Stony	6	0	104.94	81.73	115.56	38.43	4.49	0.87	0.31	0.13	0.04	346.50
	Mud	0											
	Mud and sand	0											
	Total	7	0	101.14	80.14	105.94	33.35	3.85	0.74	0.27	0.11	0.03	325.57
III			No tows					No tows				No tows	
IV	Sand	0											
	Stony	4	0	0.32	2.19	11.51	8.54	1.94	0.37	0.37	0.20	0.36	25.80
	Mud	0											
	Mud and sand	0											
	Total	4	0	0.32	2.19	11.51	8.54	1.94	0.37	0.37	0.20	0.36	25.80
Total	Sand	1	0	78.33	70.60	48.20	2.87	0	0	0	0	0	200.00
	Stony	10	0	63.09	49.92	73.94	26.47	3.47	0.67	0.33	0.16	0.17	218.22
	Mud	0											
	Mud and sand	0											
Summer 1950													
I	Sand	0											
	Stony	1	0	6.60	132.96	6.23	2.44	0.68	0.09	0	0	0	149.00
	Mud	0											
	Mud and sand	0											
	Total	1	0	6.60	132.96	6.23	2.44	0.68	0.09	0	0	0	149.00
II	Sand	1	100.00	2.64	25.80	3.24	3.62	0.55	0.15	0	0	0	136.00
	Stony	5	5.20	77.23	176.97	6.86	4.79	2.57	0.35	0.03	0	0	274.00
	Mud	0											
	Mud and sand	0											
	Total	6	21.00	64.80	151.77	6.26	4.59	2.23	0.32	0.03	0	0	251.00
III	Sand	0											
	Stony	1	3.00	0	0	0	0.01	0.85	0.77	0.89	0.26	0.22	6.00
	Mud	0											
	Mud and sand	0											
	Total	1	3.00	0	0	0	0.01	0.85	0.77	0.89	0.26	0.22	6.00
IV	Sand	0											
	Stony	4	0.30	0.58	3.58	4.50	8.21	6.41	1.34	0.43	0.13	0.24	25.72
	Mud	0											
	Mud and sand	2	0	0	2.60	2.44	5.48	9.02	3.99	1.54	0.43	0.21	25.71
	Total	6	0.20	0.39	3.25	3.81	7.30	7.28	2.23	0.80	0.23	0.23	25.72
Total	Sand	1	100.00	2.64	25.80	3.24	3.62	0.55	0.15	0	0	0	136.00
	Stony	11	2.75	35.92	93.83	5.32	5.38	3.64	0.72	0.25	0.07	0.11	147.99
	Mud	0											
	Mud and sand	2	0	0	2.60	2.44	5.48	9.02	3.99	1.54	0.43	0.21	25.71
Spring 1950													
I	Sand	0											
	Stony	1	0	0	6.04	1.59	1.44	1.24	0.55	0.13	0.01	0	11.00
	Mud	0											
	Mud and sand	0											
	Total	1	0	0	6.04	1.59	1.44	1.24	0.55	0.13	0.01	0	11.00
II	Sand	1	0	2.00	42.73	6.78	5.81	2.44	0.24	0	0	0	60.00
	Stony	6	0	42.30	41.93	6.61	9.79	5.67	1.09	0.45	0.10	0.13	108.07
	Mud	0											
	Mud and sand	0											
	Total	7	0	36.54	42.05	6.63	9.22	5.21	0.97	0.39	0.09	0.11	101.21
III			No tows					No tows				No tows	
IV	Sand	0											
	Stony	4	0	29.90	8.57	0.33	0.59	0.82	0.24	0.13	0.04	0.18	40.80
	Mud	0											
	Mud and sand	1	0	0	0	0	0	0	0	0	0	0	0
	Total	5	0	23.92	6.86	0.27	0.47	0.66	0.19	0.10	0.03	0.14	32.64
Total	Sand	1	0	2.00	42.76	6.78	5.81	2.44	0.24	0	0	0	60.03
	Stony	11	0	33.95	26.54	3.87	5.69	3.50	0.73	0.30	0.07	0.13	74.78
	Mud	0											
	Mud and sand	1	0	0	0	0	0	0	0	0	0	0	0

Table A-7.--Numbers per tow of each age by bottom type and depth zone. Subarea M

Depth zone	Bottom type	Number of tows	Age group 0	1	2	3	4	5	6	7	8	9 +	Total
							Summer 1948						
	Sand	4	0.30	0.30	0	0	0	0	0	0	0	0	0.60
	Stony	1	0	0	0	0	0	0	0	0	0	0	0
I	Mud	1	0	0	0	0	0	0	0	0	0	0	0
	Mud and sand	0											
	Total	6	0.20	0.20	0	0	0	0	0	0	0	0	0.40
	Sand	10	0	2.06	4.07	1.63	0.41	0.23	0.33	0.33	0.13	0.07	9.26
	Stony	2	0	4.40	4.60	0	0	0	0	0	0	0	9.00
II	Mud	0											
	Mud and sand	0											
	Total	12	0	2.45	4.16	1.36	0.34	0.19	0.28	0.28	0.11	0.06	9.23
	Sand	1	20.00	0	0	0.50	0.40	0.10	0	0	0	0	21.00
	Stony	3	0	0.10	0.20	0	0	0	0	0	0	0	0.30
III	Mud	0											
	Mud and sand	0											
	Total	4	5.00	0.08	0.15	0.13	0.10	0.03	0	0	0	0	5.49
	Sand	2	0	0	0	0	0	0	0	0	0	0	0
	Stony	0											
IV	Mud	0											
	Mud and sand	0											
	Total	2	0	0	0	0	0	0	0	0	0	0	0
	Sand	17	1.25	1.28	2.39	0.99	0.27	0.14	0.19	0.19	0.08	0.04	6.82
	Stony	5	0	1.82	1.96	0	0	0	0	0	0	0	3.78
Total	Mud	1	0	0	0	0	0	0	0	0	0	0	0
	Mud and sand	0											
							Summer 1949						
	Sand	3	0	0	0	0	0	0	0	0	0	0	0
	Stony	4	0	43.80	0	0	0	0	0	0	0	0	43.80
I	Mud	0											
	Mud and sand	0											
	Total	7	0	25.03	0	0	0	0	0	0	0	0	25.03
	Sand	13	0.40	604.46	41.32	44.01	16.45	6.44	1.47	0.73	0.30	0.09	715.67
	Stony	1	4.00	156.60	22.35	33.01	21.39	9.25	6.19	2.98	0.94	0.29	257.00
II	Mud	0											
	Mud and sand	0											
	Total	14	0.66	572.47	39.96	43.23	16.80	6.64	1.81	0.89	0.35	0.11	682.91
	Sand	0											
	Stony	3	0	0.31	1.33	0.85	0.65	0.45	0.24	0.10	0.05	0.02	4.00
III	Mud	0											
	Mud and sand	0											
	Total	3	0	0.31	1.33	0.85	0.65	0.45	0.24	0.10	0.05	0.02	4.00
IV			No tows						No tows				No tows
	Sand	16	0.33	491.12	33.57	35.76	13.37	5.23	1.20	0.59	0.24	0.07	581.48
	Stony	8	0.50	41.59	3.29	4.45	2.92	1.33	0.86	0.41	0.14	0.04	55.53
Total	Mud	0											
	Mud and sand	0											
							Summer 1950						
	Sand	2	0	40.11	133.27	0.90	0.50	0.19	0.03	0	0	0	175.00
	Stony	2	0	0	0	0	0	0	0	0	0	0	0
I	Mud	0											
	Mud and sand	1	0	39.41	112.70	2.38	1.31	0.97	0.10	0	0	0	156.87
	Total	5	0	23.93	75.85	0.83	0.46	0.27	0.03	0	0	0	101.37
	Sand	13	0.20	32.36	81.72	1.64	1.06	0.80	0.23	0.22	0.15	0.12	118.50
	Stony	2	0	5.73	151.86	7.08	2.25	0.94	0.12	0.02	0	0	168.00
II	Mud	0											
	Mud and sand	0											
	Total	15	0.17	28.81	91.07	2.36	1.22	0.82	0.22	0.19	0.13	0.11	125.10
	Sand	1	0	0	1.36	0.63	0.72	0.25	0.04	0	0	0	3.00
	Stony	1	0	0	0	0	0	0	0	0	0	0	0
III	Mud	0											
	Mud and sand	0											
	Total	2	0	0	0.68	0.32	0.36	0.12	0.02	0	0	0	1.50
IV			No tows						No tows				No tows
	Sand	16	0.16	31.31	83.14	1.48	0.97	0.69	0.19	0.18	0.12	0.10	118.34
	Stony	5	0	2.29	60.74	2.83	0.90	0.38	0.05	0.01	0	0	67.20
Total	Mud	0											
	Mud and sand	1	0	39.41	112.70	2.38	1.31	0.97	0.10	0	0	0	156.87
							Spring 1950						
	Sand	4		0	137.71	14.11	17.17	10.23	2.74	0.72	0.05	0.04	182.77
	Stony	3		0	0.30	63.44	9.06	8.43	3.81	0.83	0.31	0.06	86.24
I	Mud	0											
	Mud and sand	0											
	Total	7		0	78.82	35.25	13.69	9.46	3.20	0.77	0.16	0.05	141.40
	Sand	10		42.80	53.72	3.58	4.75	2.05	0.26	0.04	0	0	107.20
	Stony	1		2.00	125.23	4.80	6.03	0.94	0	0	0	0	139.00
II	Mud	0											
	Mud and sand	0											
	Total	11		39.09	60.22	3.69	4.87	1.95	0.24	0.04	0	0	110.09

Table A-7.--Numbers per tow of each age by bottom type and depth zone. Subarea M - Continued

Depth zone	Bottom type	Number of tows	Age group 0	1	2	3	4	5	6	7	8	9 +	Total
							Spring 1950 - Continued						
III	Sand	1	0	0	0	0	0	0	0	0	0	0	0
	Stony	2	9.91	2.26	1.78	0.54	0.01	0	0	0	0	0	14.50
	Mud	0											
	Mud and sand	0											
	Total	3	6.61	1.51	1.19	0.36	0.01	0	0	0	0	0	9.67
IV			No tows						No tows			No tows	
Total	Sand	15	28.53	72.53	6.15	7.75	4.09	0.90	0.22	0.01	0.01		120.21
	Stony	6	3.64	21.79	33.11	5.71	4.37	1.91	0.41	0.15	0.03		71.12
	Mud	0											
	Mud and sand	0											

Table A-8.--Numbers per tow of each age by bottom type and depth zone. Subarea N

Depth zone	Bottom type	Number of tows	Age group 0	1	2	3	4	5	6	7	8	9 +	Total
							Summer 1948						
	Sand	5	15.80	0	0	0	0	0	0	0	0	0	15.80
	Stony	0											
I	Mud	0											
	Mud and sand	0											
	Total	5	15.80	0	0	0	0	0	0	0	0	0	15.80
	Sand	14	38.80	16.19	15.17	1.02	0.16	0.37	0.12	0.06	0.01	0	71.81
	Stony	0											
II	Mud	0											
	Mud and sand	0											
	Total	14	38.80	16.19	15.17	1.02	0.16	0.37	0.12	0.06	0.01	0	71.81
	Sand	3	0.30	0	0	0	0	0	0	0	0	0	0.30
	Stony	0											
III	Mud	0											
	Mud and sand	4	0	0	0	0	0	0	0	0	0	0	0
	Total	7	0.13	0	0	0	0	0	0	0	0	0	0.13
IV			No tows				No tows			No tows			
	Sand	22	28.32	10.25	9.65	0.65	0.10	0.24	0.08	0.04	0.01	0	49.33
	Stony	0											
Total	Mud	0											
	Mud and sand	4	0	0	0	0	0	0	0	0	0	0	0
							Summer 1949						
	Sand	6	0.20	207.38	0.92	0	0	0	0	0	0	0	208.50
	Stony	0											
I	Mud	0											
	Mud and sand	0											
	Total	6	0.20	207.38	0.92	0	0	0	0	0	0	0	208.50
	Sand	12	1.70	40.38	0.32	0	0	0	0	0	0	0	42.40
	Stony	0											
II	Mud	0											
	Mud and sand	0											
	Total	12	1.70	40.38	0.32	0	0	0	0	0	0	0	42.40
	Sand	2	0	0	0	0	0	0	0	0	0	0	0
	Stony	0											
III	Mud	0											
	Mud and sand	3	0	0	0	0	0	0	0	0	0	0	0
	Total	5	0	0	0	0	0	0	0	0	0	0	0
	Sand	0											
	Stony	0											
IV	Mud	0											
	Mud and sand	1	0	0	0	0	0	0	0	0	0	0	0
	Total	1	0	0	0	0	0	0	0	0	0	0	0
	Sand	20	1.08	86.44	0.47	0	0	0	0	0	0	0	87.99
	Stony	0											
Total	Mud	0											
	Mud and sand	4	0	0	0	0	0	0	0	0	0	0	0
							Summer 1950						
	Sand	5	0	2.75	3.90	0.16	0.21	0.18	0.05	0.06	0.06	0.03	7.40
	Stony	0											
I	Mud	0											
	Mud and sand	0											
	Total	5	0	2.75	3.90	0.16	0.21	0.18	0.05	0.06	0.06	0.03	7.40
	Sand	11	65.10	4.38	19.96	0.38	0.62	0.73	0.73	0.44	0.18	0.11	92.63
	Stony	1	22.00	0	0	0	0	0	0	0	0	0	22.00
II	Mud	0											
	Mud and sand	0											
	Total	12	61.51	4.01	18.30	0.35	0.57	0.67	0.67	0.40	0.16	0.10	86.74
	Sand	0											
	Stony	0											
III	Mud	0											
	Mud and sand	5	0	0	0	0	0	0	0	0	0	0	0
	Total	5	0	0	0	0	0	0	0	0	0	0	0
IV			No tows				No tows			No tows			
	Sand	16	44.76	3.87	14.94	0.31	0.49	0.56	0.52	0.32	0.14	0.09	66.00
	Stony	1	22.00	0	0	0	0	0	0	0	0	0	22.00
Total	Mud	0											
	Mud and sand	5	0	0	0	0	0	0	0	0	0	0	0
							Spring 1950						
	Sand	8		3.90	344.26	5.55	3.89	2.11	0.49	0.20	0.06	0.04	360.50
	Stony	0											
I	Mud	0											
	Mud and sand	0											
	Total	8		3.90	344.26	5.55	3.89	2.11	0.49	0.20	0.06	0.04	360.50
	Sand	12		0.10	31.59	0.92	1.11	1.48	0.50	0.32	0.08	0.18	36.28
	Stony	0											
II	Mud	0											
	Mud and sand	0											
	Total	12		0.10	31.59	0.92	1.11	1.48	0.50	0.32	0.08	0.18	36.28

Table A-8.--Numbers per tow of each age by bottom type and depth zone. Subarea N - Continued

Depth zone	Bottom type	Number of tows	Age group 0	1	2	3	4	5	6	7	8	9 +	Total
			Spring 1950 - Continued										
III	Sand	1		0	0	0	0	0	0	0	0	0	0
	Stony	0											
	Mud	0											
	Mud and sand	4		34.40	0	0	0	0	0	0	0	0	34.40
	Total	5		27.52	0	0	0	0	0	0	0	0	27.52
IV				No tows					No tows			No tows	
Total	Sand	21		1.54	149.20	2.64	2.11	1.65	0.47	0.26	0.07	0.12	158.06
	Stony	0											
	Mud	0											
	Mud and sand	4		34.40	0	0	0	0	0	0	0	0	34.40

Table A-9.--Numbers per tow of each age, by bottom type and depth zone. Subarea 0

Depth zone	Bottom type	Number of tows	Age group 0	1	2	3	4	5	6	7	8	9 +	Total
			Summer 1948										
	Sand	4	0	0	0	0	0	0	0	0	0	0	0
	Stony	0											
I	Mud	2	0	0	0	0	0	0	0	0	0	0	0
	Mud and sand	2	0.50	0	0	0	0	0	0	0	0	0	0.50
	Total	8	0.13	0	0	0	0	0	0	0	0	0	0.13
	Sand	8	24.50	0.15	1.25	0.35	0.57	0.22	0.04	0.02	0	0	27.10
	Stony	0											
II	Mud	4	1.30	0	0	0	0	0	0	0	0	0	1.30
	Mud and sand	4	5.50	0	0	0	0	0	0	0	0	0	5.50
	Total	16	13.95	0.07	0.62	0.18	0.29	0.11	0.02	0.01	0	0	15.25
	Sand	0											
	Stony	0											
III	Mud	1	0	0	0	0	0	0	0	0	0	0	0
	Mud and sand	2	0	0	0	0	0	0	0	0	0	0	0
	Total	3	0	0	0	0	0	0	0	0	0	0	0
IV			No tows				No tows			No tows			
	Sand	12	16.32	0.10	0.83	0.23	0.38	0.15	0.03	0.01	0	0	18.07
	Stony	0											
Total	Mud	7	0.74	0	0	0	0	0	0	0	0	0	0.74
	Mud and sand	8	2.88	0	0	0	0	0	0	0	0	0	2.88
			Summer 1949										
	Sand	4	0	0	0	0	0	0	0	0	0	0	0
	Stony	0											
I	Mud	0											
	Mud and sand	1	0	1109.78	58.22	0	0	0	0	0	0	0	1168.00
	Total	5	0	221.96	11.64	0	0	0	0	0	0	0	233.60
	Sand	6	0	1.76	0.04	0	0	0	0	0	0	0	1.80
	Stony	0											
II	Mud	5	0	0	0	0	0	0	0	0	0	0	0
	Mud and sand	5	0	15.03	0.77	0	0	0	0	0	0	0	15.80
	Total	16	0	5.35	0.26	0	0	0	0	0	0	0	5.61
	Sand	0											
	Stony	0											
III	Mud	1	0	0	0	0	0	0	0	0	0	0	0
	Mud and sand	2	0	0	0	0	0	0	0	0	0	0	0
	Total	3	0	0	0	0	0	0	0	0	0	0	0
IV			No tows				No tows			No tows			
	Sand	10	0	1.06	0.02	0	0	0	0	0	0	0	1.08
	Stony	0											
Total	Mud	6	0	0	0	0	0	0	0	0	0	0	0
	Mud and sand	8	0	148.12	7.76	0	0	0	0	0	0	0	155.88
			Summer 1950										
	Sand	6	0	0	0	0	0	0	0	0	0	0	0
	Stony	0											
I	Mud	1	0	0	0	0	0	0	0	0	0	0	0
	Mud and sand	3	0.70	0	0	0	0	0	0	0	0	0	0.70
	Total	10	0.21	0	0	0	0	0	0	0	0	0	0.21
	Sand	10	56.20	0	0	0	0	0	0	0	0	0	56.20
	Stony	0											
II	Mud	2	2.50	0	0	0	0	0	0	0	0	0	2.50
	Mud and sand	1	32.00	0	0	0	0	0	0	0	0	0	32.00
	Total	13	46.08	0	0	0	0	0	0	0	0	0	46.08
	Sand	0											
	Stony	0											
III	Mud	1	0	0	0	0	0	0	0	0	0	0	0
	Mud and sand	0											
	Total	1	0	0	0	0	0	0	0	0	0	0	0
	Sand	0											
	Stony	0											
IV	Mud	0											
	Mud and sand	2	0.50	0	0	0	0	0	0	0	0	0	0.50
	Total	2	0.50	0	0	0	0	0	0	0	0	0	0.50
	Sand	16	35.13	0	0	0	0	0	0	0	0	0	35.13
	Stony	0											
Total	Mud	4	1.25	0	0	0	0	0	0	0	0	0	1.25
	Mud and sand	6	5.85	0	0	0	0	0	0	0	0	0	5.85

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